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JOURNAL
# of the
Bombay Natural History Society

Vol. 75, No. 3

Editors : J. C. Daniel, P. V. Bole & A. N. D. Nanavati

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NOTICE TO CONTRIBUTORS

Contributors of scientific articles are requested to assist the editors by observing the following instructions:

1. Papers which have at the same time been offered for publication to other journals or periodicals, or have already been published elsewhere, should not be submitted.

2. The MS. should be typed (double spacing) on one side of a sheet only, and the sheets properly numbered.

3. All scientific names to be printed in italics should be underlined.

4. Trinomials referring to subspecies should only be used where identification has been authentically established by comparison of specimens actually collected.

5. Photographs for reproduction must be clear and show good contrast. Prints must be of a size not smaller than 8.20 × 5.60 cm (No. 2 Brownie) and on glossy glazed paper.

6. Text-figures, line drawings, and maps should be in Indian ink, preferably on Bristol board.

7. References to literature should be placed at the end of the paper, alphabetically arranged under author's name, with the abridged titles of journals or periodicals underlined (italics) and titles of books *not* underlined (roman type), thus:

Banerji, M. L. (1958): Botanical Exploration in East Nepal. *J. Bombay nat. Hist. Soc.* *55*(2):243-268.

Prater, S. H. (1948): The Book of Indian Animals. Bombay. Titles of papers should not be underlined.

8. Reference to literature in the text should be made by quoting the author's name and year of publication, thus: (Banerji 1958).

9. *Synopsis*: Each scientific paper should be accompanied by a concise, clearly written synopsis, normally not exceeding 200 words.

10. *Reprints*: Authors are supplied 25 reprints of their articles free of charge. In the case of joint authorship, 50 copies will be given gratis to be distributed among the two or more authors. Orders for additional reprints should be in multiples of 25 and should be received within two weeks after the author is informed of the acceptance of the manuscript. They will be charged for at cost plus postage and packing.

11. The editors reserve the right, other things being equal, to publish a member's contribution earlier than a non-member's.

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EDITORIAL

The editorial to the Golden Jubilee issue of the *Journal* volume 50(4) described the history of the first fifty issues of the Journal published between the years 1886 to 1952. The Journal then had four issues per volume and hence the additional 16 years to complete fifty volumes.

With this issue and 26 years later we complete the 75th volume of the Journal. The comments made in the introductory paragraphs of the 50th issue editorial apply equally well today and are quoted below.

> "For a natural history publication conducted by a private society purely out of revenues derived from its membership subscriptions, with practically no financial aid from Government or extraneous sources, this is indeed a praiseworthy achievement. Add to this the general lack of interest in natural history in India that had to be contended with for keeping up the Society's membership strength, also the fact that contributions for publication were gratis and voluntary and therefore not always to be depended on—and the achievement becomes doubly creditable.
>
> The contributions to the Journal at first consisted largely of sporting and popular articles written mostly by members of the Society who were generally observant sportsmen and field naturalists—'amateurs' it is true, but in the best sense of the term. The scope of these contributions has steadily expanded, and serious scientific papers by acknowledged experts have now become a regular feature of its pages.
>
> Finally, the fact that throughout the years the editors of the Journal have all been entirely honorary—business or professional men with plenty of enthusiasm but limited time at their disposal is not the least notable feature of this remarkable achievement."

It would also be useful to quote the objectives of the *Journal* as published in the 1st volume dated January 1886.

> "In accordance with the character which this Society has assumed from the beginning, the aim of its journal will be, as far as possible, to interest all students of nature, ever remembering that there are many naturalists, in the highest sense of the term, who have not such a technical knowledge of any particular branch of science as to be able to enter with interest into questions of nomenclature and the discrimination of closely allied species. The Secretaries of the Sections would therefore invite sportsmen and others to communicate anything interesting or worthy of note, which comes under their observation, bearing on the nature and habits of animals and plants."

Today perhaps only the miscellaneous notes meet these objectives. The *Journal* has become more technical for the methods of enquiry have become more sophisticated. Apart from technical papers the *Journal* today leans more towards conservation and ecology of wildlife. Hunting as a sport has almost no room in present day conditions and the members prefer to look at nature through the camera than over the sights of a gun. The natural history notes are equally rewarding, however, and the photographs are a better trophy as witness the works of Loke Wan Tho, E. P. Gee and M. Krishnan which have appeared in this last quarter of the *Journal's* history.

This issue of the *Journal* blends the old and the new not only subjectwise but also in the authors. Several contributions being from persons trained at the Society.

It would pertinent to list the editors who had, with the same zeal as was exhibited by their predecessors of the first 50 volumes maintained its high standards.

The Editors' Who's When

Vol. 51 (1952-53) Sálim Ali, S. B. Setna, H. Santapau

Vol. 52-56 (1954-59) Sálim Ali, H. Santapau

Vol. 57-59 (1960-62) H. Santapau, H. Abdulali

Vol. 60-61 (1963-64) H. Santapau, Z. Futehally

Vol. 62-63 (1965-66) H. Santapau, D. E. Reuben, Z. Futehally, J. C. Daniel

Vol. 64-67 (1967-70) H. Santapau, Z. Futehally, J. C. Daniel

Vol. 68-70 (1971-73) Z. Futehally, J. C. Daniel, P. V. Bole

Vol. 71-75 (1974-78) J. C. Daniel, P. V. Bole, A. N. D. Nanavati

The Editors' Who's Who

1. Humayun Abdulali

One of India's leading ornithologists and author of two regional checklists. He was the Society's Honorary Secretary from 1954 to 1962 when there were many changes in its organisation. It was the period when the Society cut its umbilical chord with Phipson & Co. and the Natural History Section of the Prince of Wales Museum. His most notable contribution was the successful negotiation with the Government of India and the Prince of Wales Museum for the building to house the Society's offices—Hornbill House.

2. Sálim Ali

Sálim Ali has had a long and active association with the Society. His chief interest is birds, particularly the field aspects of their study, and he is the author of several books on Indian birds. He served as one of the editors in 1927-28 (vols. 32 and 33), and resumed his connection with the Journal in 1944 (vol. 45), collaborating with S. H. Prater and C. McCann. Upon their leaving India, Sálim Ali took over as General Editor assisted by Dr. S. B. Setna for a year, when Fr. H. Santapau joined the board. His editorial association with the Journal terminated when he commenced work on the 10 vol. HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN. He continues to serve the Society as its President and Doyen.

3. P. V. Bole

Professor of Botany at St. Xavier's College, Bombay is actively associated with the Blatter Herbarium and the Society for almost 30 years. He has contributed papers on floristics of W. India, plant ecology and survey of economic plants as well as on ethnobotany. Interested in conservation of natural habitat and propagation of indigenous plants for breeding purposes.

4. J. C. Daniel

Studied at the Madras Christian College and the Madras University Zoology Research Laboratory. He joined the Society as a Research Assistant in 1950. Joined the Natural History Museum at Darjeeling as Curator in 1955 and returned to the Society as its Curator in 1960. His interest in natural history are eclectic, with a leaning towards reptiles and wildlife conservation.

5. Zafar Futehally

Took over from Humayun Abdulali as Honorary Secretary. An avid birdwatcher, Zafar has the ability to communicate his enthusiasm to others. It was during his stewardship that the Society stopped being introspective and widened the scope of its activities. Zafar has been the founder of the Birdwatchers' Field Club of India and editor since its inception in 1960 of the Newsletter for Birdwatchers' now in its 19th volume.

6. A. N. D. Nanavati

Was the first medical man to take over the administration of the Society. A virologist, he was Asstt. Director of the Haffkine Institute at Bombay till his premature retirement in 1974. Dr. Nanavati's dispassionate assessment of issues has strengthened the Society's handling of problems that arise.

7. D. E. Reuben

An ex member of the ICS who retired as Chief Justice of Bihar before settling in Bombay. Mr. Reuben's meticulous hand was of considerable help when Sálim Ali retired as Executive Editor. Mr. Reuben though his name was on the editorial board only very briefly was a de facto editor of the Journal over several volumes.

8. H. Santapau

Studied at the Imperial College of Science and Technology, London, and in Kew Gardens and specialized in Plant Taxonomy. He was particularly interested in the botany of Western India and has done intensive explorative work in Khandala, Purandhar, Mahableshwar and in Saurashtra. He was director of the Biology Department of St. Xavier's College, Bombay. Fr. Santapau was later the Director of the Botanical Survey of India.

9. S. B. Setna

Studied under Dr. J. Gray, Professor of the Zoological Laboratory, Cambridge University, where he obtained his Ph.D. degree. He was the Director of Fisheries, Bombay State, since the inception of the department in 1945. In this capacity he was responsible for the development of freshwater and marine fisheries in the State and also for the maintenance of the Taraporevala Aquarium. He was elected a Fellow of the National Institute of Science of India in 1947 and was awarded the first Chandra Kala Hora Memorial Gold Medal in 1950 for conspicuously important contributions to the development of the fishing industry.

Costs then and now

In 1891 four issues of the Journal with 6 coloured plates printed in England cost Rs. 4316.

In 1900 the Journal cost including 10 colour plates was Rs. 6338.

In 1930 the cost of a volume with 10 colour plates was Rs. 15562.

In 1952 the cost was similar approximately Rs. 15000 but without any colour plates.

In 1960 a volume of three issues cost Rs. 20,811.86.

In 1970 the cost of volume of three issues was Rs. 34,773.

In 1977 the cost was Rs. 60,117.73.

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SOCIETY

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BOMBAY NATURAL HISTORY SOCIETY—
The Founders, the Builders and the Guardians
Part 1

Salim Ali

(*With four plates*)

On the eventful completion of the 75th volume of the Society's *Journal* after an unbroken run of publication since its inception in 1886, it is pertinent to look back and take stock of the men who contributed to the building up of the prestige it now enjoys as a scientific periodical within the country and abroad. For a small private Society started by a tiny group of eight nature loving residents of Bombay in 1883 for 'exchanging notes, exhibiting interesting specimens, and otherwise encouraging one another'* to have risen to its present stature is a saga of achievement for gratification and pride. All the more praiseworthy is the success when it is remembered that the Society never was an affluent institution and has always had a hand-to-mouth existence, dependent more or less entirely on the modest annual subscriptions derived from its regrettably meagre membership. How then was the Society able to achieve so much? This was surely due overwhelmingly to the sagacity and foresight of its dedicated Founders, Builders and Guardians—the men who were directly responsible for the conduct of its affairs over the years—and those who nurtured it with their pioneering attainments in the field of natural history, and with their original scientific contributions to its developing publication. All honour to these men, but who were they? To answer this question, and at this distance of time, I felt it would be worthwhile to research the obituaries that have been published in the *Journal* from the earliest days. Between the year 1903, when the first obituary appears in Vol. 14 (there are none in the preceding 13 volumes), and the latest in 1973 in Vol. 70—104 in all, though we know of some others who have escaped mention. They are notices chiefly of men who in various ways contributed significantly enough to the reputation of the Society and the *Journal* to be remembered with special gratefulness. Apart from the persons responsible for the material well being of the Society, the Founders and the Builders, I have selected a number of others, the Guardians—scientists, field naturalists and sportsmen—who by their researches and their experiences and writings, or by their prowess as hunters, or their zeal as nature conservationists have aided substantially in the evolutionary process of the Society. Fortunately this category is not strictly confined to the names in the obituaries: we still have many living amongst us today who by their diverse benefactions are helping to add lustre to the Society and scientific prestige to its journal and thus to keep its image shining.

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* 'The Founders of the Bombay Natural History Society' by W. S. Millard, Vol. 35: 196.

First priority in this Roll of Honour must of course be accorded to the Founders, and the Builders who followed them. The excerpts here culled from the obituary notices in the *Journal* deal mainly with the nature of their respective associations with the Society, but I have included such additional information as was readily available from other sources. For more biographical particulars the interested reader is referred to the *Journal*, (volume and page indicated in brackets after each name).

The Founders

EDWARD HAMILTON AITKEN ('EHA') 1851-1909
(Vol. 19: 540) by T. R. B(ell)

The son of a Scottish missionary, born in Satara and educated in Bombay. He served first in the Education Department and later in the Customs. He retired to Edinburgh in 1906 and died two years later of Bright's Disease.

EHA was one of the eight original founders of the Society in 1883 and co-editor with R. A. Sterndale of the earliest issues of the *Journal*. He was interested in all branches of Zoology, but particularly so in birds and insects, chiefly butterflies. For many years he was in charge of the Society's Entomological Section, a position which he took over from Lionel de Nicéville on the latter's death in 1901. He had a special genius for seizing the striking and characteristic points in the appearance and behaviour of individual species, and a happy knack of translating them into print so as to render his descriptions unmistakable. He was a shrewd observer of humanity too as his book BEHIND THE BUNGALOW testifies. This book is an Anglo-Indian classic and will remain a lasting monument to the memory of the author. His first literary venture was entitled THE TRIBES ON MY FRONTIER describing the animals ordinarily met with in and around an Indian bungalow. Another book of his is THE COMMON BIRDS OF BOMBAY which treats of the birds met in the town of Bombay and its vicinity in a manner that makes it easy for anyone to recognize each individual when he sees it. A less known book THE NATURALIST ON THE PROWL written when he was in Kanara and 'full of the scent of the jungles' is perhaps less generally known. All his books are full of accurate knowledge pleasantly imparted, and with a quaint humour which cannot but appeal to the reader, and the joyousness of living which expresses so well the nature of the writer. Aitken was the first Honorary Secretary of the Society and continued as such till his departure from Bombay. The first number of the *Journal* was produced in January 1886. It met the need for putting on permanent record whatever was of value or interest transacted at the Society's meetings. In introducing the first number the editors expressed the hope that "The introduction of this Journal will stimulate lovers of Nature to record and communicate their observations." This hope has been more than realized, and the papers published in the *Journal* since its commencement have borne splendid testimony to the debt owed by naturalists in India to Messrs Aitken and Sterndale.

The late Sir Norman Kinnear related to me (SA) an amusing story connected with EHA's death. The parish newspaper of the obscure little Scottish village to which EHA's father had belonged, thought it its duty to publish a fitting obituary of such a distinguished son of the village. The editor had probably never heard of the man or his interests and writings until his death got reported in outside newspapers. However, not to be outdone by his city confreres he ingeniously added to EHA's laudatory qualifications that "Mr. Aitken who had lived all his life in India was an expert on Frontier Tribes and Bungalow Economy."!

A surprising detail I also gleaned from Sir Norman was that inspite of his humorous and seemingly effortless style EHA was in fact a slow writer and usually had to do a lot of laborious scratching out, re-writing, and meticulous chipping, changing and polishing before he was satisfied with his compositions.

Col. CHARLES SWINHOE M.A. (Oxon) 1836-1923 (Vol. 29: 1042) Anon.

Another of the 8 founders of the Society in 1883. He reached India just after the Mutiny of 1857 and served with the Bombay Staff Corps, evidently largely in Sind, till his retirement in 1893. He went through the Afghan War and was with Lord Roberts in Kandahar. Col. Swinhoe was a man of many parts: a keen shikari of the old school who had accounted for between 50 and 60 tigers, and a devotee of most outdoor sports. He was interested in birds. A collection of 70 skins made by him in Sind and presented to the Society is listed in Vol. 2: 56. There is an incredible statement by E. C. Stuart Baker both in the FAUNA OF BRITISH INDIA, Birds (Vol. 5, p. 268) and in his GAME BIRDS OF INDIA, BURMA AND CEYLON (Vol. 2, p. 269) that Col. Swinhoe obtained three specimens of the Coronetted Sandgrouse (*Pterocles coronatus atratus*) at Dhar in the Mhow area of Madhya Pradesh, which is entirely out of the bird's distributional range. An examination of the original collector's label still intact on one of these skins (now in the British Museum collection) shows that the specimens were actually obtained by Col. Swinhoe at "Maiwund" [near Kandahar] in February 1881, therefore evidently during the campaign in Afghanistan. However, it was as an entomologist that he attained international fame. He published on "The Lepidoptera of Karachi and its Neighbourhood" in Volumes 2 and 3 of the *Journal*. On the death of Frederick Moore, Col. Swinhoe was entrusted with the completion of that magnificent work on Indian butterflies LEPIDOPTERA INDICA; the portions dealing with the Lycaenidae (Blues), Hesperidae (Skippers), and a part of the Pieridae (Whites) were compiled entirely by him. But, the Heterocera or Moths is the section in which he excelled; of these he had amassed a collection of 40,000 specimens comprising 7000 different species. It included no less than 400 types of the new species described by him. He remained active to his 87th year, just before which he had completed "A revision of the genera of the family Liparidae" covering some 1130 detailed entries. Col. Swinhoe was universally recognized as an expert on all matters connected with Lepidoptera and was the recipient of many international honours for his services to entomology. He was well known as a lecturer on such subjects as mimicry. A paper of his on "Mimicry in Butterflies for Protection" appears in Vol. 2: 169.

JOHN COUSSMAKER ANDERSON 1851-1930
(Vol. 35: 185) by W.S.M.(illard)

Son of General William Coussmaker Anderson; born at Dharwar, Bombay Presidency. Read at Inner Temple and was called to the Bar. Came out to India in 1878 and practised in the Bombay High Court for 25 years. Retired from India in 1901.

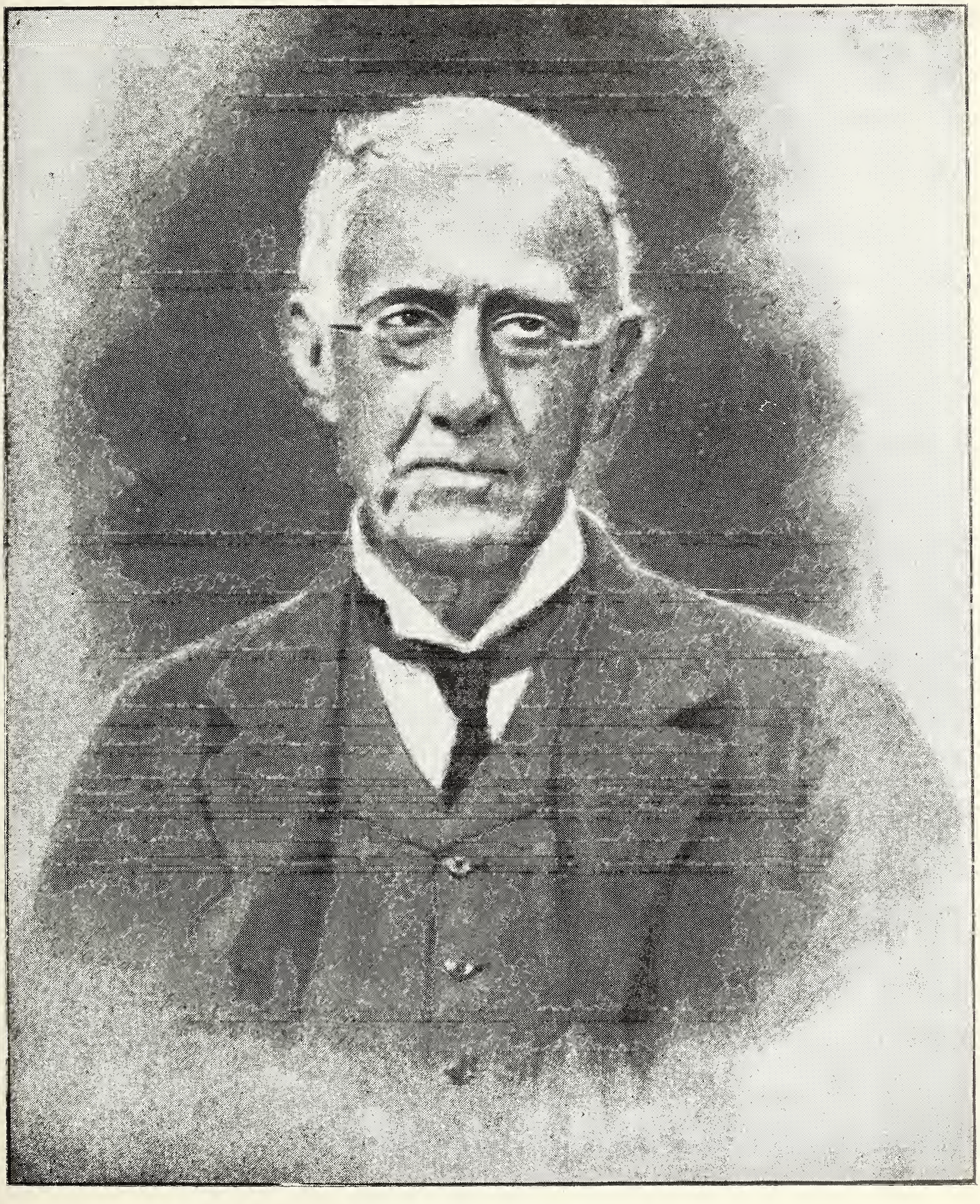
J. C. Anderson was one of the eight original founders of the Society. "He was a keen lover of Nature and helped the Society in many ways." In Vol. 4(1) 1889 there is an interesting paper by him entitled "Sporting Rambles round about Simla", and he presented to the Society's museum a large number of specimens of birds and mammals collected by him in the Simla neighbourhood.

HERBERT MUSGRAVE PHIPSON 1850-1936
(Vol. 39: 152) Anon.

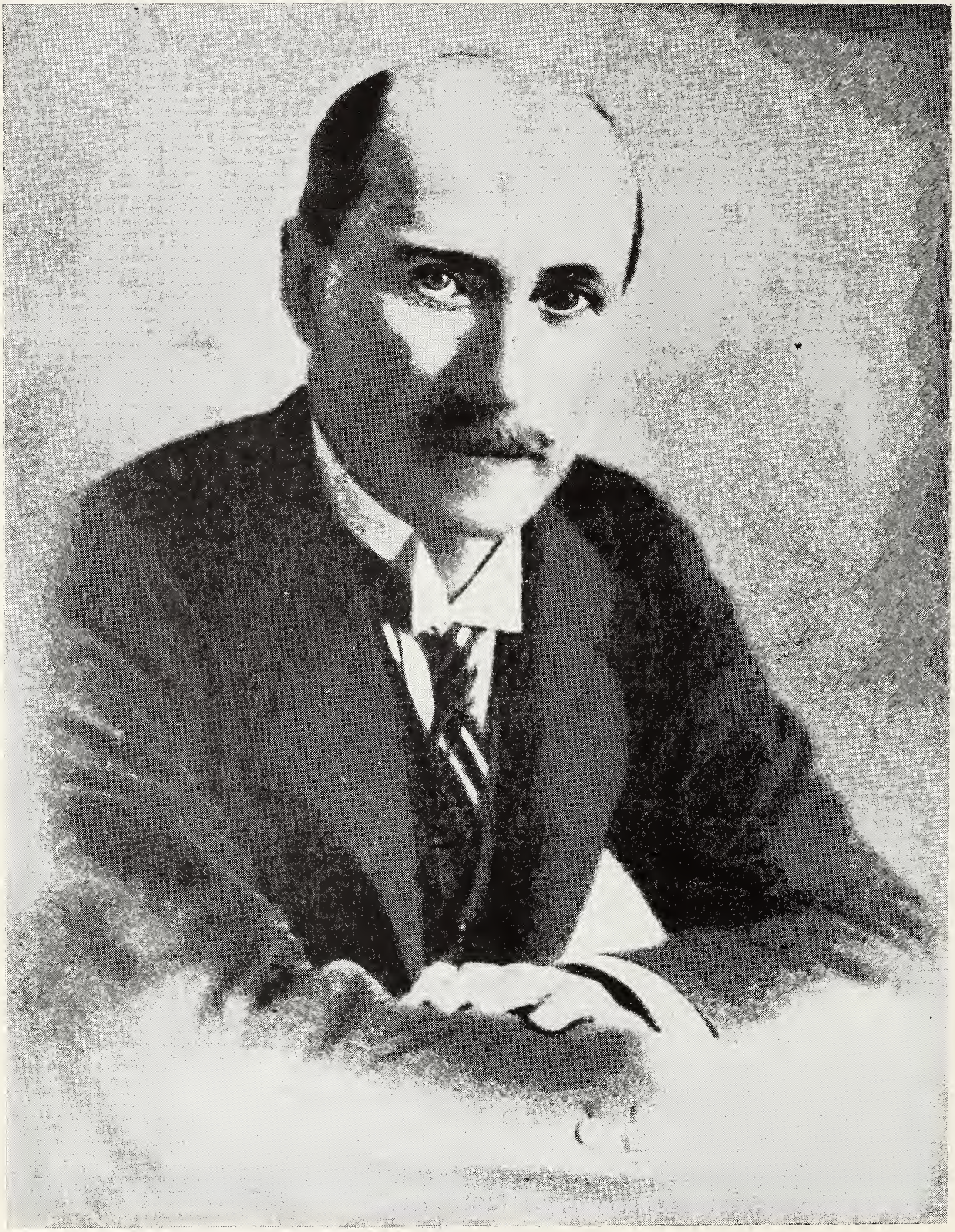
Son of T. W. Phipson, Q.C. of Lincoln's Inn. First came out to India in 1878. Established the firm of Phipson & Co., Wine Merchants, in 1883; left India in 1906. He was in England when the eight original founders of the Society met at the Victoria & Albert Museum, Bombay, on 15 September 1883. He joined the Society on his return from England in the same year, and in January 1884 offered a room in his offices at 18 Forbes Street as a more central place for the Society's meetings and for keeping its collections. The removal of the Society's offices to a central situation in the city, and Phipson's enthusiastic association with it, gave an astonishing impulse to its growth. The need for finding better accommodation for its rapidly increasing collections becoming urgent, Phipson again provided the solution by offering the Society part of the larger premises he had acquired at 6 Apollo Street (now Shaheed Bhagat Singh Road). The Society's collections and offices were transferred there in 1886, and remained until 1958, when the gracious old single-storeyed colonial type building (the former residence of the Chief Justice of Bombay) was due to be pulled down to give way to an ugly 'modern' concrete monster. Phipson's interest in natural history and his zeal for the Society were contagious. He interested his numerous friends in the Society's work and imparted his devotion to the young men who came out to India to assist him in his business. His advice to the young European in India was 'develop a hobby', and to him there was no finer hobby than natural history. Thus commenced, and thus continued, the long association of the Society with the Company which bears Phipson's name. His successors in business took over his post of Honorary Secretary and Editor of the *Journal* and have each in their time made their contribution to the Society's progress.

Fom March 1886, when he took over the office of Honorary Secretary from E.H. Aitken—more familiarly known from his books as EHA—to April 1906 when he left India, Phipson was the heart and soul of the Society. Initiating and directing its early activities he brought it to vigorous maturity. Through these twenty years he edited the Society's *Journal*—for a year in collaboration with Robert Sterndale, then as sole editor for 15 years, and finally jointly with W. S. Millard, his immediate successor in office.

His business and the management of the Society's affairs left Phipson little time for contributing in print the wide knowledge he had acquired of the Indian natural history of



Herbert Musgrave Phipson
1850-1936



Walter Samuel Millard
1864-1952

which his favourite branch was Snakes. His rare contributions to the *Journal* centre round this subject, and among them is a paper on 'Poisonous Snakes of the Bombay Presidency' (Vol. 2, p. 244). In his day Phipson was the presiding genius of the Society, which had come to be known as 'Phipson's Museum'. He welcomed visitors great and small and taking them round the collections would treat them to a wealth of interesting facts and anecdotes drawn from his wide fund of knowledge and experience. He was charming: always interesting and ever ready with shrewd and amusing comment. The numerous offers of live animals which the Society was receiving gave Phipson the idea of establishing a zoological garden conducted and managed by the Society. What at first seemed a promising venture failed because the Municipality were unwilling to allow the use of the site selected by Phipson for the purpose. In his ambition to provide Bombay with a really fine natural history museum Phipson was more successful; the admirable Natural History section of the Prince of Wales Museum is largely the fruit of his initiative and exertions. Phipson's name as a naturalist is fittingly commemorated by zoologists describing several new discoveries after him, e.g. the sea snake *Hydrophis phipsoni* (=*H. cyanocinctus*), the earth snake *Silybura phipsoni* (= *Uropeltis rubrolineatus*), the scorpion *Isometrus phipsoni*, the whip scorpion *Phrynicus phipsoni* and the galeod spider *Rhagodes phipsoni*. The beautiful flying squirrel *Petinomys phipsoni*, though discovered by the Society's Mammal Survey long after his departure from India, was also named in his honour to perpetuate the memory of his dedicated association with the Society and with Indian natural history. The Society owes a tremendous debt to Phipson for its growth and prosperity, and the prestige it now enjoys. Few men have striven more earnestly and more continuously to advance such a purely unselfish cause, and few have laboured for the advancement of science and for the general good in a more self-effacing and unobtrusive spirit. Phipson was always ready to help anyone, and as one friend with whom he lived observed 'He monopolized the self-denial of the whole house!'

WALTER SAMUEL MILLARD 1864-1952 (Vol. 50, p. 910—photo) by N. B. Kinnear

Seventh son of Rev. J. H. Millard of Huntingdon, England. Came out to Bombay as assistant to Herbert Musgrave Phipson in his wine business in 1884, by which time Phipson & Co. along with Bombay Natural History Society had shifted to 6 Apollo Street. To reach his office it was necessary to pass through the Society's museum which, in addition to various stuffed animals and jars containing fish and reptiles, generally housed a live cobra or two and a large python. Millard joined the Society soon after his arrival and in 1893 was made assistant editor of the *Journal* though he had doubtless been helping Phipson with the work of the Society for some time previously. On Phipson's retirement from India in 1906, Millard took his place in the Society and as editor of the *Journal* which, under Phipson's editorship, had become the most important scientific publication east of Suez. The Society's journal remained unique among scientific publications in the East since it not only published important scientific papers but also natural history and shikar articles of general interest to readers. It was through Millard's personal interest, and under his careful supervision of details when on leave in England, that Stuart Baker's serial on 'Indian Ducks and their Allies', which had started in the *Journal* as long ago as 1897 was published by the Society in book form. It proved an immediate success, and ran out of print faster than anticipated. He followed up the success of this first major venture of the Society by the publication of the two other volumes on Game Birds by Stuart Baker, THE PALMS OF INDIA by Fr. E. Blatter and BEAUTIFUL INDIAN TREES by himself and Fr. Blatter. The title of the last is slightly misleading since it includes a number of trees that are not Indian. Though Millard took interest in natural history generally, his particular hobby was gardening, especially the cultivation of flowering trees and shrubs. The grounds of the bungalow where he lived on Malabar Hill, Bombay, were soon developed into a beautiful garden with a great variety of trees and shrubs and a large fernery full of foliage plants, orchids and other tropical flowers. It was the most important private garden at the time, and "guests staying at Government House were frequently sent to inspect its treasures". He took a deep and active interest in beautifying the city by introducing attractive flowering trees in different localities. Among the more outstanding of his introductions are the Burmese *Cassia renigera* and the Padauk *Pterocarpus indicus* with fragrant yellow flowers which, inspite of its name, is also a native of Burma. One tree of the latter species he had planted in the grounds of Bombay University, and such was his continuing interest in his introductions that years after he had left India for good in 1920, he wrote to the Society enquiring how this particular tree was thriving! Millard, on the goading of R. C. Wroughton, a retired Indian Forest Officer, was instrumental in launching the much needed Mammal Survey of India, Burma and Ceylon, 1910-14, when it had to be terminated on the outbreak of World War I. The vast collections made by the survey in different parts of the erstwhile 'British Indian Empire' provided the basis for the publication of the standard volumes on the mammalian fauna of the subcontinent by Pocock and Ellerman. The starting and success of the Mammal Survey was entirely due to Millard, and only those who were in close association with him at the time have any idea of the amount of time and work he spent in the raising of the money and the organizing of the survey. All this was done in addition to attending to the Society's other business and editing the *Journal*, to say nothing of looking after his own business of Messrs Phipson and Co. and the many other honorary social and charitable activities in which he was involved.

Every visitor to the Society's rooms in Apollo Street will remember the Great Indian Hornbill, better known as 'William' or the 'Office Canary', which lived in a cage behind Millard's chair in Phipson & Co.'s office for 26 years and died in 1920, soon after Millard left India. It is said that death was caused by swallowing a piece of wire, but in the past 'William had swallowed a lighted cigar without ill effects and Millard's obituarist—a colleague—firmly believed that the loss of his old friend was the principal cause.

By nature Millard was of rather a shy and retiring disposition, but all that vanished when he had anything to do on behalf of the Society. His wife Sybil assisted her husband in many ways, and her presence at the meetings of the Society was always welcome, where her charming personality made the shy visitor feel at ease.

It was the routine in BNHS during Millard's secretaryship that every afternoon at 2.30, after the lunch hour, the accountant Baburao (?) would bring up his Day Book, ledger and vouchers to be checked. Baburao, loaded with the books, would first timidly push the spring door ajar and peep in. Then, on a nod from Millard he would nervously tiptoe in. As soon as he got to his desk, Millard would look up and over his reading glasses straight into the man's eyes and with mock solemnity declaim "Baburao I suspect you! Whenever you are making an entry in your cash book say to yourself 'Mr. Millard suspects me!' That will keep you out of temptation."

I (SA) personally have very special cause for gratefulness to Millard for the inordinate amount of interest he took in that diffident little schoolboy who once approached him with the mangled carcase of a Yellowthroated Sparrow for identification, in the year 1906 or thereabouts. It was largely the fatherly encouragement I received from him at the time, and continuingly thereafter, that set me off on a lifetime of enjoyable and rewarding bird study.

NORMAN BOYD KINNEAR 1882-1957 (Vol. 54: 928—photo) by S. H. Prater

The son of C. H. G. Kinnear an Edinburgh architect, he started his natural history career as a voluntary worker in the Royal Scottish Museum at Edinburgh under the expert guidance of Dr. Eagle Clarke, the Director, and a distinguished ornithologist. He came out to India in 1907 as the Society's first stipendiary Curator to organize and look after the considerable zoological collections, particularly of vertebrates, that had been amassed by its enthusiastic amateur members from all over the erstwhile 'Indian Empire' during the first quarter century or so of the Society's progress and development. Till then this mass of material, housed in the Society's rooms at 6 Apollo Street, was looked after and maintained by several keen and devoted amateurs who gave up their evenings after office hours to this work—and one callow youth fresh from school who served as a general factotum!

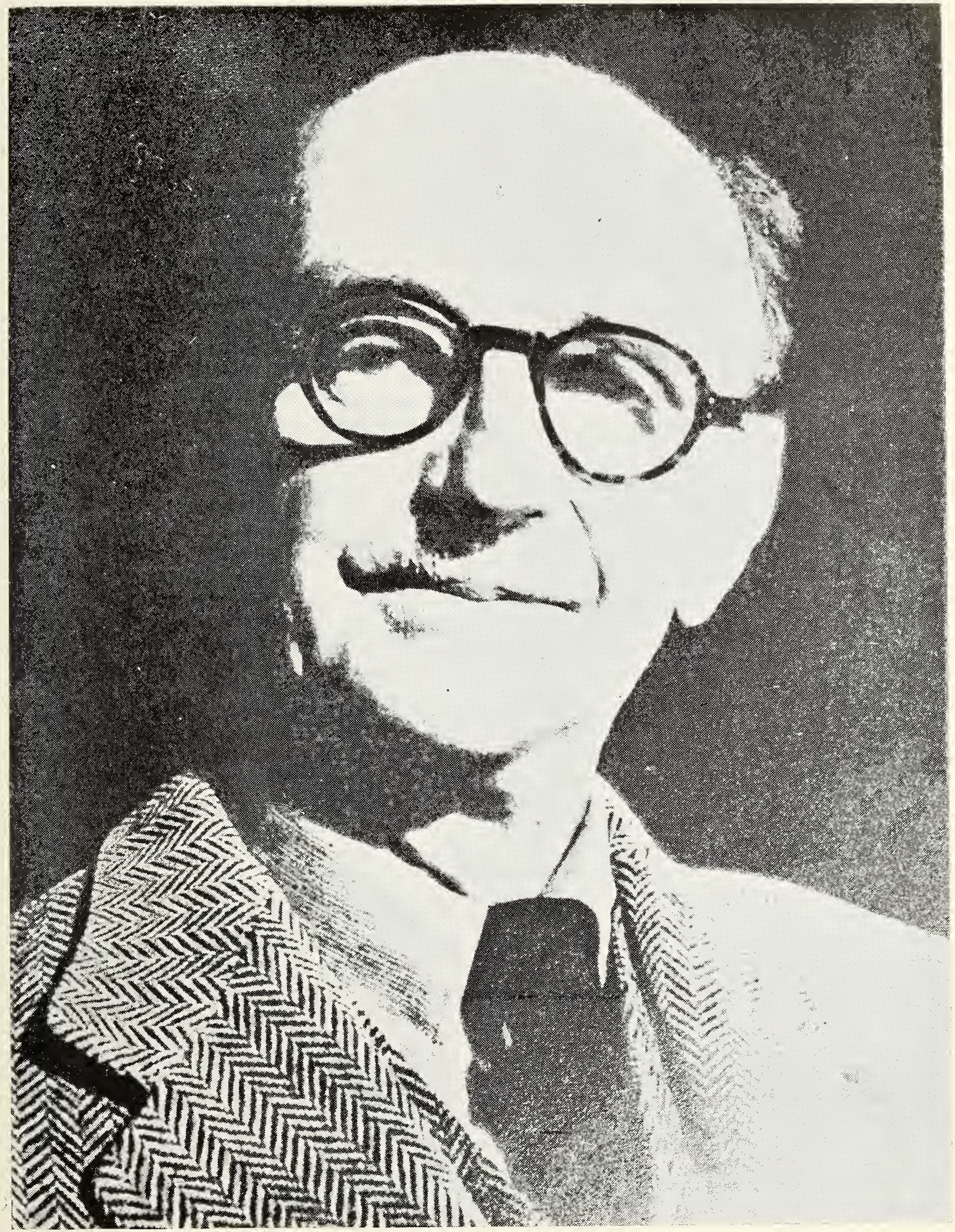
Kinnear gave invaluable service to the Society by placing the whole of its museum on a sound scientific basis through the rearrangement, labelling and cataloguing of the collections. His gift for organization and meticulous attention to detail not only benefitted the museum as a whole but also contributed substantially to the training of the small staff working under him. He also provided more effective assistance to members of the Society who sought his help, and generally guided the work in directions which produced greater scientific gains. Kinnear threw himself wholeheartedly into the direction and control of the systematic survey of the Mammals of India, Burma and Ceylon which the Society had started with the preliminary spadework of Millard. He identified the geographical areas that needed to be worked by the collectors with special coverage of those where earlier mammalogists had obtained Types but which were missing, with a view to replacing them by Topotypes. To him fell the arduous task of assembling the enormous collections obtained by the Mammal Survey; of provisionally identifying and cataloguing them and arranging for their despatch to the British Museum in London. The great advances in systematic mammalogy through the medium of the Survey were largely due to Kinnear's organization and the painstaking care with which the preliminary work was carried out. During World War I when Kinnear was attached to Brigade Headquarters in Bombay as Intelligence Officer, he constantly encourged members of the Society serving with the Expeditionary Force in Mesopotamia to make collections of mammals, birds, reptiles and insects for the Society and kept up a voluminous and painstaking correspondence of helpful instructions, advice and guidance with them. He found time to prepare a pamphlet on the 'Animals of Mesopotamia' for circulating among the officers and men and thus provided an invaluable reference book for all those who were collecting specimens. The scientific results of the large zoological collections so accumulated appeared in a series of papers in the Society's *Journal* between the years 1918 and 1923 and are a fitting tribute to Kinnear's intimate involvement in the enterprise. To his building the Society owes the progress and development of its museum on sound scientific lines, and the staff the training which stood them in such good stead in after years. Kinnear, who during his tenure as Curator also served as one of the editors of the *Journal*, resigned his post in 1919 to take up a special appointment as assistant in the Bird Department of the British Museum where he steadily rose to become Assistant Keeper of Zoology and then Keeper, finally ending up as Director of the Museum in 1947. He had contributed outstandingly to the progress of the Society and is remembered by all who knew him as a kindly and generous helper and friend. Since Kinnear's resignation the Society had undertaken the Vernay Scientific Survey of the Eastern Ghats, an area whose ornithology was very imperfectly known. The important bird collections obtained by this Survey were worked out by him in collaboration with Hugh Whistler, another distinguished ornithologist, and the results are published in the Society's *Journal* under their joint authorship. Kinnear was knighted in 1950.

PHILIP MCDONELL SANDERSON 1884-1957
(Vol. 54: 930—photo) by R. A. Spence

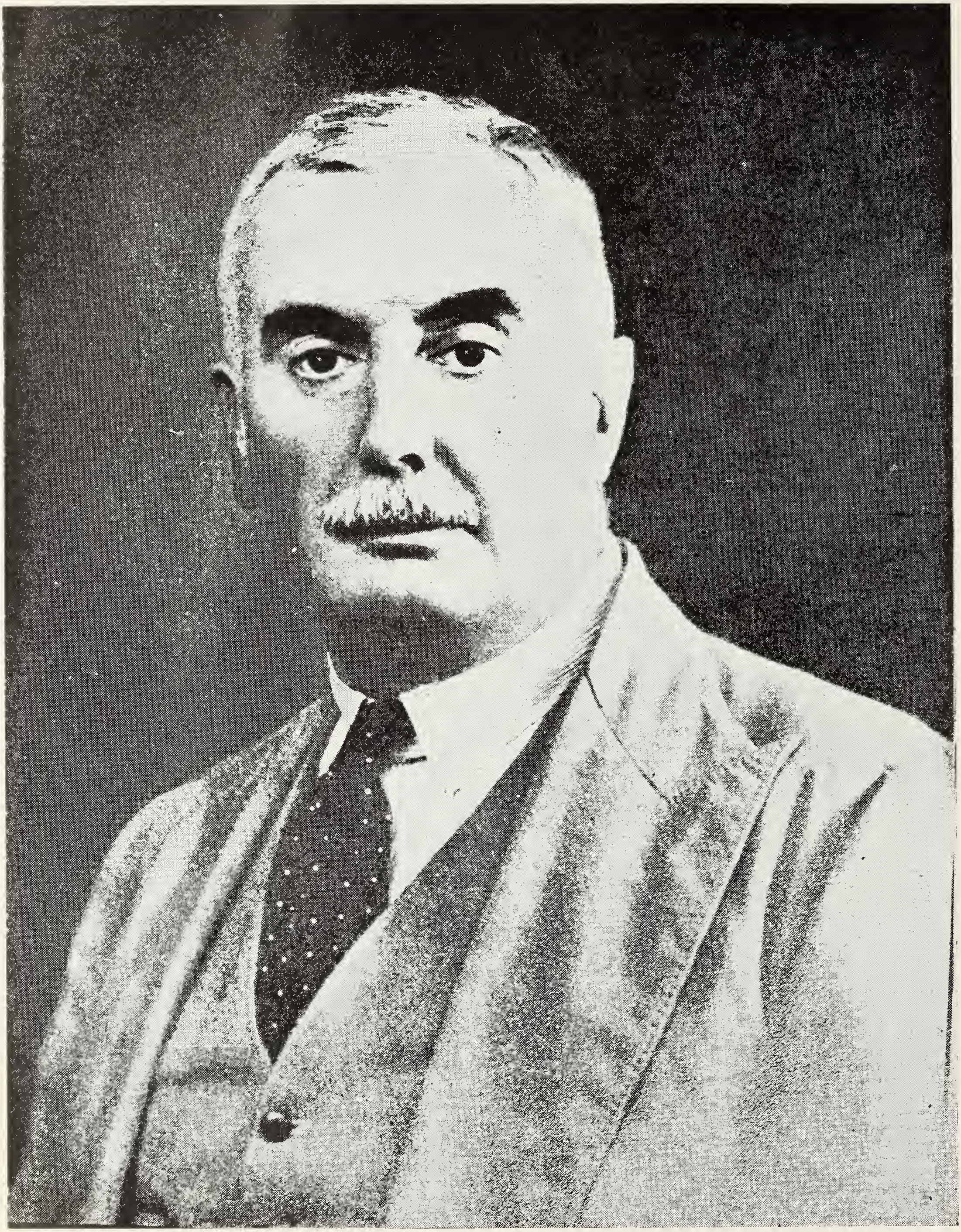
The son of Launcelot Sanderson a former master of Harrow School. He came out to India in 1905 to join the firm of Phipson & Co. the partners in which, H. M. Phipson and W. S. Millard, were responsible for the nurture of the Society's *Journal* and museum. With Phipson and Millard as co-workers, it was natural that Sanderson took an interest in the Natural History Society's affairs, and this was increased when Norman Kinnear came out to work in the Society's museum in 1907. He joined up on the outbreak of World War I in 1914 and saw service in Mesopotamia where he was badly wounded during the trench battles for the relief of Kut. He was a popular officer, and "Because he was so thin he was known among his men as 'Pull-through' and to us, from the resemblance of his nose to the Great Hornbill in Phipson's office, as 'The Bird'."

When W. S. Millard left India in March 1920, Sanderson joined R. A. Spence as Joint Honorary Secretary of the Society and, with Norman Kinnear, the three edited the *Journal*. In 1934 he became the sole Honorary Secretary and edited the *Journal* with the help of S. H. Prater and later, Sálim Ali. Sanderson was very keen on Prater's work to make a real Museum of Natural History in the Prince of Wales Museum, and he had the privilege of running the arrangements for the Golden Jubilee of the Society in 1933 and the formal opening of the Natural History section. He left India in 1939 on the outbreak of the Second War, and later took over from Millard as the Society's representative in England.

Sanderson was a good natured extrovert, hail-fellow-well-met with all visitors to the Society's rooms, and in many ways a useful public relations man for the Society. But his uninhibited light-hearted banter sometimes unwittingly landed the Society in awkward situations, as for instance in the case of the long



Philip McDonell Sanderson
1884-1957



Reginald A. Spence
1880-1961

forgotten review of a pot-boiler shikar book published in the *Journal* which led to the Society and the reviewer having to pay considerable legal damages to the allegedly aggrieved author years afterwards! He was a keen yachtsman and small game hunter, but left no significant mark as a naturalist or in his capacity as Honorary Secretary since he left the running of the Society largely in the able hands of the Curator, S. H. Prater.

STANLEY HENRY PRATER 1890-1960 (Vol. 57: 637—photo) by Sálim Ali

Born in the Nilgiris, died in London, the son of William Prater, a coffee planter in S. India. From his early schooldays in Khandala he came under the influence and tutelage of such distinguished Jesuit naturalists as the Rev. Fathers Dreckmann (snakes), Assmuth (termites) and Blatter (plants), who fostered his interest in natural history. Prater joined the Society's service in 1907, first working under the guidance of E. Comber and later as assistant to the first stipendiary Curator, N. B. Kinnear. After a 4-years' probationary period following the latter's resignation in 1919 Prater was confirmed as Curator of the Society and of the Natural History Section of the Prince of Wales Museum which was then under its management. To qualify him for the stewardship of a really first class natural history museum, which the Prince of Wales aimed to become, he was deputed by the Board of Trustees in 1923 to the United Kingdom to learn the art of modern taxidermy, and in 1927 he was again sent abroad to study the techniques of modern natural history museum exhibition and management in England and America. The fruits of all the skill and aptitude he thus acquired are evidenced by the artistically designed exhibition galleries and the superb dioramas, in the Natural History Section, acclaimed to be the finest in the East. The outstanding progress made by the Society between the years 19[illegible] and 1937 was due entirely to the dynamic combination of two dedicated personalities, namely Sir Reginald Spence and S. H. Prater, the former as Honorary Secretary of the Society and Chairman of the Board of Trustees of the Prince of Wales Museum, and the latter as the versatile Curator. He possessed the gift of transmitting the knowledge and experience gained abroad to his co-workers and staff in a way that extracted their whole-hearted cooperation and helped to achieve the highest results. The Natural History Section is a standing monument to Prater's genius. He was fortunate in having as his lieutenant an exceptionally competent naturalist and skilful craftsman in the person of Charles McCann. McCann readily lapped up the imported techniques, adapted them to local needs and conditions, and put them into masterly execution in the museum's galleries.

For nearly a quarter of a century prior to his retirement in 1948 Prater's name was almost synonymous with the Bombay Natural History Society. For the last 27 years of his service he was the executive editor of the *Journal* and was largely responsible for the high standard and international recognition it earned as the foremost natural history periodical in Asia. He was a voracious reader, particularly of natural history books and journals, and had a flair for guzzling through heavy scientific literature, then picking out the essentials of what he read and translating the substance into simple jargon-free language for the layman. He was blessed with a remarkably retentive memory and could usually lay his hands on anything he had read on a subject, maybe years before, without hesitation or fumbling. Prater's *forte* was compilation—an art in which he excelled. He wrote in a readable, easy and often humorous style, and his many contributions in the *Journal* convey an idea of the wide range of his natural history interests and his versatility. The familiarity he acquired with the Society's natural history collections during his long stewardship gave him a wonderful all round grasp of Indian animals. Though his own leanings were more particularly towards mammals, birds and snakes he was equally at home with almost all other groups, and could not only name straightway practically any specimen brought in by members, but usually also give something of their distribution and habits. His intimate involvement with mammals during the Society's Mammal Survey between 1911 and 1923, both as a field collector and while handling specimens as they came in from the field or back from the British Museum after identification, accounts largely for the authenticity and success of his BOOK OF INDIAN ANIMALS, first published by the Society in 1948 and now in the 4th edition. The crying need for wildlife preservation in India was brought home to the public and the government largely by his able exposition in the Introduction to the admirable series on 'Wild Life Preservation in India' which he initiated in the *Journal* in 1935, and by his constant 'plugging' of the problem through numerous well-informed editorials, and newspaper articles before and since. Prater was in truth a remarkable man—capable, versatile, sociable, ambitious, and a striver after perfection as many of his handiworks clearly show. His sociable disposition, keen sense of humour and considerateness for his subordinates and staff endeared him to all who came in contact with him. He will deservedly enjoy an honoured place in the annals of the Society as one of its most stalwart and capable builders.

REGINALD A. SPENCE 1880-1961 (Vol. 58: 776) by Editors, JBNHS

Came out to Bombay in 1901 as assistant in the firm of Phipson & Co. then under the management of H. M. Phipson and W. S. Millard. From the very beginning of the Society Phipsons have been closely associated with it. In keeping with this tradition Spence took an active interest in the Society's welfare, and on Millard's retirement from India in 1920 took over as Honorary Secretary, continuing to serve in this capacity until he left India in 1934. During this period the Society expanded its activities in several fields including the establishment of the Natural History Section in the Prince of Wales Museum. This was achieved predominantly through the untiring efforts of Sir Reginald Spence who was also Chairman of the Board of Trustees of the Prince of Wales Museum. The negotiations begun by his predecessors H. M. Phipson and W. S. Millard for the transfer to the Government of Bombay of the financial responsibility for the housing and proper care of the Society's collections were finalized by him, and detailed plans for the beautiful n Natural History wing of the Prince of Wales Museum were drawn up before he left India though he was not here to see them actually carried out. Spence's genial personality won him many friends, and the esteem in which he was held by the public and the Government was of immense value to the Society. Spence was one of the editors of the *Journal* from 1907 to 1933. Towards the end, owing to the increasing demands on his time by business and public-spirited social work he had to leave much of the actual editing to his col-

Norman Boyd Kinnear
(1882-1957)

Stanley Henry Prater
(1890-1960)

leagues. His outstanding contributions to the *Journal*, both written jointly with S. H. Prater, are 'The fish supply of the west coast of India' (Vol. 34: 973, 35: 77) and 'Game fishes of Bombay, the Deccan and the neighbouring districts of the Bombay Presidency' (Vol. 36: 29). He was knighted in the year 1926 and left India to settle in England in 1934.

(*To be continued*)

CHANGES IN THE BIRD FAUNA OF A FOREST AREA; SIMLIPAL HILLS, MAYURBHANJ DISTRICT, AND DHENKANAL DISTRICT, ORISSA

S. Dillon Ripley[1]

In this world of uncertainty, nothing is more certain than the fact that no single state of nature ever quite stays the same. Ecological studies have shown over and over the fallacy of surveying a spatial area of land or water, documenting the population composition of species, and from those terms of reference assuming that stability can be proved to have been the rule at a later period of time. Such fallacious assumptions have been developed in the past in surveys by government agencies for the setting up of parks or reserves.

As no accurate method seems to have been devised for measuring the amount of space which a complex of interacting species in nature need to survive in balance, and to maintain a reproductive minimum critical size, aside of course for some classic laboratory observations, it seems likely that the study of parks or reserves and their creation, is far more complicated than previously thought, and requires much further refinement. Biological and ecological research, coupled with the development of mathematical models would seem to be a priority in assessing the future of species themselves as well as the preservation of suitable habitat.

A case in point may be the observations made by Dr. Salim Ali, my wife and myself in Mayurbhanj District, in the Simlipal Hills of Orissa in February, 1975 and southwards. Here we were fortunate enough to spend three weeks of observation from Chahala in the north, south to the Mahanadi River and the adjacent Dhenkanal District. During this visit we were the guests of the Government of Orissa, whose forestry service, under then Deputy Secretary Shri D. K. Chatterjee I.A.S., Mr. Jee, Chief Conservator of Forests, Mr. Das, the Department Wildlife coordinator, all were kindness itself. Our special thanks are due to Shri Saroj Chaudury, the special Conservator of Wildlife and the great tiger authority, for his generosity and help to us during our visit.

Dr. Sálim Ali and I had both visited and made observations in the hills of northern Orissa in 1947, twenty-eight years before. We thus, in perhaps a somewhat crude way, were able to compare observations of the occurrence of bird species in the same area over a quarter century apart. Obviously these notes are perhaps of only marginal significance, but it seems worthwhile to write them here, due to the paucity of field observations in this interesting area. It is to be hoped that Sálim Ali's collections of 1947 will eventually be at least listed with localities. and published in order to give a baseline against which to judge later collecting and field observations. In my own case observations alone must suffice.

Once we entered the reserved forest areas of the Simlipal Hills of Mayurbhanj on February third, 1975, it became rapidly apparent that we were in a virtual monoculture situation. The tropical dry deciduous or moist deciduous forests of these areas are completely dominated by a monotonous planting of sal, *Shorea robusta,* which has been rigorously cultivated as a dominant forest product. Relatively mature plantations of these trees ranging in age from 25-60 years occupy the landscape as an exercise in silviculture. The understorey in these vast stretches of plantation is similarly monotonous with strobilanthes, ferns and grasses present being dominant, presumably due to fire and man-made clearing. As Champion and Seth state (1968:121), "Planned forest management has intensified its (sal) dominance in many areas by selective removal of other competing species." However, these authors do not speculate on the consequences of this enforced dominance.

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[1] Smithsonian Institution, Washington, D.C. 20560, U.S.A.

Here and there one can still find small irregularities, nullahs where sal has not been planted. In these nullahs depending on steepness and general size, may be found patches of so-called "miscellaneous forest," in the forester's term, and here remnant samplings of tropical moist deciduous forest species occur. Here we found rattan and pandanus, examples of Terminalias, *Bombax, Cassia fistula, Adina, Erythrina* and *Dillenia* as examples.

Whether these patches represent original forest or are secondary, the result of shallow stony soil conditions, exposure, erosion and cutting through activities of the Kohl and Khariya people is hard to say. Some of each tribal group have now been employed for two generations in the promotion of these forest reserves, and the forests are continually being seasonally burned and cleared of undergrowth. In any case, here and there one had at least a temporary impression that in the thickest parts of these clumps along a stream bed, there still occurs a microclimate approaching the tropical semi-evergreen type of vegetation, especially in the presence of a few stands of climbers like rattan, *Calamus* ssp., *Pandanus,* and bamboos, including the thorny *B. arundinacea, Dendrocalamus strictus,* and *Imperata* grass.

In 1947, these stands of sal were less prevalent in the sense that much less of the plantation form was in evidence, more mixed jungle remained, and consequently there was a different, less parklike, less artificial situation. Both of us were struck by the extreme paucity of birds in the thick stands of sal. We were impressed by the occurrence of birds along the stream beds and remnant patches of miscellaneous forest. Only here and there flowering bushes, *Woodfordia* or *Indigofera* were left along the roadside, might one see small birds such as sunbirds or honeyeaters attracted to feed, passing through the sal plantation enroute.

A good deal of current literature concerns the important observation that, "the diversity of bird species increases with increasing vegetation diversity," (Mulsow 1977), although most of the current studies are being undertaken in temperate Western Europe and North America. Bezzel (1974, 1976, 1977) has studied breeding bird populations with grid-mapping and has shown clearly that unchecked economic expansion affects bird populations directly. Therefore "the quality of an environment can be measured by its birdlife," and ecological planning as well as impact assessment can be developed through bird study. This is paralleled in the work of Reichholf (1973-1976) on butterflies, Egloff and Brakel (1973) on stream pollution and a diversity index, Tramer and Rogers (1973) on fish population in streams, and Woodwell (1974) on biotic impoverishment, and numerous other papers such as Lack and Lack (1951).

In our own case we had fourteen days of observations in these areas of reserved forest.

In the sal plantation areas, we found on the average only the following species working their way through the mid-storey of the forest below the closed leafy canopy (for in this area sal has only a two to three week period of being deciduous at the end of the dry season):

I. SPECIES OBSERVED IN SAL PLANTATIONS.

Number (from SYNOPSIS, 1961)
501. *Treron bicincta*
987. *Sturnus malabaricus*
1067. *Tephrodornis virgatus*
1070. *Tephrodornis gularis*
1091. *Pericrocotus cinnamomeus*
1264a. *Turdoides striatus* (flocks pass through sal plantations)
1419. *Muscicapa westermanni*
1448. *Culicicapa ceylonensis*
1503. *Prinia hodgsonii*
1590. *Phylloscopus inornatus*
1838. *Sitta frontalis*
1892. *Dicaeum agile* (flowering bushes, e.g. *Woodfordia*)
1917. *Nectarinia asiatica* ,, ,, ,,
1927. *Aethopyga siparaja* ,, ,, ,,
1933. *Zosterops palpebrosa*
1949. *Petronia xanthocollis*

II. Species observed in "miscellaneous forest", i.e. tropical dry deciduous and patches of tropical moist deciduous, perhaps the closest to "moist peninsular valley sal" of Champion and Seth (1968). I exclude open country species observed during our visit such as waterbirds including lapwings, owlets such as *Athene brama*, bush-larks, jungle crow, common bulbuls, migrant shrikes, pipits and wagtails, seen frequently along streams in winter. The following list then is essentially of the closed forest:

II. SPECIES OF PATCHES OF CLOSED FOREST

138. *Accipiter badius*
211. *Falco peregrinus*
278. *Galloperdix lunulata*
299. *Gallus gallus*
504. *Treron phoenicoptera*
511. *Ducula badia*
542. *Chalcophaps indica*
557. *Psittacula cyanocephala* (on flowering trees)
617. *Otus scops*
631. *Bubo zeylonensis*
636. *Glaucidium radiatum*
642. *Ninox scutulata*
671. *Caprimulgus indicus*
682. *Caprimulgus affinis*
709. *Hemiprocne longipennis*
710. *Harpactes fasciatus*
775. *Anthracoceros coronatus* (heard locally but now increasingly rare due to human predation for medicinal purposes.)
780. *Megalaima zeylanica* (forest patches in Mayurbhanj)
784. *Megalaima lineata* (forest patches in Dhenkanal dist. possibly replacing *zeylanica?*)
792. *Megalaima haemacephala*
799. *Picumnus innominatus*
810. *Picus canus*[1]
813. *Picus flavinucha*
814. *Picus chlorolophus*
830. *Dryocopus javensis* (seen in Dhenkanal dist.)
847. *Picoides mahrattensis*
851. *Picoides nanus*
861. *Chrysocolaptes lucidus*
972. *Dicrurus remifer*
973. *Dicrurus paradiseus*
1009. *Acridotheres fuscus*
1017. *Gracula religiosa* (only in Dhenkanal dist.)
1032. *Dendrocitta vagabunda*
1065. *Hemipus picatus*
1083. *Pericrocotus flammeus*

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[1] *Picus canus gyldenstolpei* represents a new record for Mayurbhanj District, another example of the presence in the northern Orissa hills of Himalayan foothill species such as the bulbul, *Pycnonotus melanicterus flaviventris*, or such babblers as *Stachyris ruficeps* and *Dumetia*, and *Macronous gularis* implying a recent distribution since the last colder, pluvial period with no subspecific or recognizable differentiation.

1103. *Chloropsis aurifrons*
?1109. *Irena puella* (an unverified sight record, which implies that this species should be looked for in the future.)
1115. *Pycnonotus melanicterus*
1154. *Pellorneum ruficeps*
1173. *Pomatorhinus schisticeps*
1210. *Stachyris ruficeps*
1222. *Dumetia hyperythra*
1228. *Macronous gularis*
1264a. *Turdoides striatus* (flocks passing through sal plantations also)
1389. *Alcippe poioicephala*
1438. *Muscicapa poliogenys*
1451. *Rhipidura aureola*
1457. *Rhipidura albicollis*
1465. *Hypothymis azurea*
1522. *Prinia sylvatica*
1578. *Phylloscopus tytleri*[2]
1604. *Phylloscopus trochiloides*
1734. *Zoothera citrina*
1831. *Sitta castanea*
1899. *Dicaeum erythrorhynchos* (near *Loranthus*)
2011. *Carpodacus erythrinus*

It is possible to state unequivocally that the bird species enumerated above preferred the "miscellaneous forest", tended to be confined there, and would be found in sal plantations only enroute from one preferred patch of habitat to another, or if, occasionally an isolated older climax forest tree should be for some random reason left isolated amidst the sal, and at the same time be in fruit or in flower. This would be an accident if it occurred. Thus our observations showed that some fifty-five species of forest birds in their habitat in Orissa are now confined to strips or ribbons of forest preserved by accident in so-called "reserved forest". This represents a factor of more than three to one in abundance of species compared to the sal plantations. Their presence is not a function of the reserved forest itself. Thus reserved forest in the sense of the term is a human artifact and not a habitat for wildlife except by accident.

Forest cultivation can therefore not be described as being in the first instance beneficial to wildlife, and an important lesson in the future survival of wild species has still to be learned. How much "miscellaneous forest" or preferred habitat for species diversity must be maintained to prevent the gradual erosion of native fauna and flora in the Indian subcontinent? Research in this subject is a priority, for it implies preservation of far more than merely obvious species such as birds, but rather all the elements in the food chain which make for natural diversity including soil constitution chemistry, and the entire web of interactions between rock, soil, bacteria, invertebrates and lower plants.

Meanwhile what of the birds we did not see? In open country vultures and kites were notable by their absence. Cuckoos were scarce, certain owls (our search for *Athene blewitti* was unavailing, Ripley 1976) were not seen, small kingfishers, and of course many passerines of numerous families and subfamilies which might occur seasonally or merely be overlooked. The net impression, however, was one of scarcity, with little if any song, and small aggregations of feeding flocks. These observations indicate the importance of field work which would include grid mapping, range plotting and extensive sampling to determine biotope health and prospects for continued environmental health all over India.

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[2] The record of *Phylloscopus tytleri* in forest near the Mahanadi River in Dhenkanal District is an interesting one as it extends the winter range considerably east from the Tapti River in M.P.

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FOREST DAYS

Tom Norman[1]

For fourteen years from 1947 to 1961 my wife and I had the privilege of living beside the forest that used to form a continuous belt between Naga Hills and the Assam Valley. Much of this forest was outside the Naga Hills District inner line, belonging administratively to the appropriate Assam Valley Districts, and covering both plains areas and the lower foothills. Like all the rain forests of S. E. Asia it teemed with a huge variety of wildlife, from elephant and sambar, birds and magnificent orchids, down to innumerable invertebrate species. Being a continuous belt, often many miles broad, it formed a corridor within which wildlife had free movement for several hundred miles, and was a self-sufficient eco-system. Now, alas, much of the forest has been cleared for cultivation from both sides of the inner line, and in the narrower parts of the belt the two clearances have met, turning the former corridor into a series of forest islands and causing the isolation of wildilfe populations. We must be thankful for what little remains, however much we may regret what has been lost. Sadly we must accept that for the present unfettered evolution in the world's rain forests has come to an end, to be replaced by a quite different form of evolution in isolated populations: it has been well worked out with regard to oceanic islands in particular that this sort of isolation leads to a rapid reduction in the total number of species and eventually to a high degree of specialisation amongst many of those that remain. Even if the Assam Government had been years ahead of world thinking on conservation, and had been able and willing to prevent forest destruction within its administrative boundary, breaks in the forest belt would still have occurred as a result of the Nagas pushing outwards and eventually taking over (and destroying) what were formerly Reserved Forests belonging to the plains Districts. Not only has evolution been interrupted: we shall now never see and record many species, some at least of which would have been of the greatest taxonomic and genetic importance. Even in a group as well known as butterflies, as late as the fifties and in an area as accessible as the forests of Sibsagar District, I was able to find very distinct species new to science.

Nostalgia and sadness for the happiness of past days and for so many losses in the conservation battle have nearly diverted me from what I had planned to be the theme of this article—the pleasantness and above all the safety of India's north-eastern rains forests, a fact which one cannot take for granted in many other parts of the world. For the fourteen years we were in Assam my wife and I spent every available spare hour in the forest. Given reasonable weather, we spent the whole of Sunday there and one afternoon a week, as well as our annual holiday of two weeks; and since my practice lay for 20 miles along the forest belt I was frequently able to have my lunch in the forest on working days. In all this time I can remember only two incidents of real fright and perhaps half a dozen others when the adrenalin began to circulate rather too fast for comfort. Normally, un-we certainly never gave it a thought.

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Of the minor nuisances, leeches and mosquitoes were always with us. Liberal appli- armed and unescorted, we felt as safe as in our own compound. Such safety from attack at all levels is taken for granted in India, and cations of di-methyl-phthalate (which has the unfortunate property of dissolving nylon) kept most of the attacking hordes at bay, but a few always got through our defences and we seldom returned without blood dripping from our feet and ankles. Nothing looks more cosy than a leech comfortably embedded between the toes! One very quickly learnt that the quickest and easiest way to deal with an attached leech was to lift it off with a finger nail under the sucker. The bite is going to go on bleeding in whatever way you may remove the creature since it has already injected anti-coagulant for this very purpose: the story that the bleeding is caused by leaving its mouthparts behind unless it has been caused to release its hold voluntarily, by e.g., the application of a lighted cigarette end, is a zoological myth. In previous times there had always been the danger that a leech bite would become infected and develop into a tropical ulcer ("Naga Sore" in Assam), but this unpleasant disease virtually disappeared in the late forties. When thinking of invertebrates I am sure that we in India were never sufficiently thankful for the absence of another pest, the various species of *Schistosoma*, so that we were able to wade or bathe in any fresh water with no danger of contracting bilharziasis—the scourge of fresh waters in Africa and further east in Asia. Neither did we have crocodiles lying in wait for us on mudbanks, nor shoals of piranhas to tear the flesh from our bones in deeper water. Scorpions I only met once in the forest, in a pile of shingle deposited by a prospecting oil company, a man-made habitat in any case. The large spiders which lurked in the tea and bit our labourers, with such unfortunate results, were never apparent in the forest, and we were mercifully spared the horror of the Black Widow and other lethally poisonous S. American and Australian spiders. On the same plane of nuisance value as the leech was the tree ant (*Oecophylla smaragdina*), whose first reaction is to nip whatever comes in its way. Brushing against one of its walk-ways, or receiving a cascade over one's head after a high shot for some choice *Arhopala*, were experiences not forgotten in a hurry, even if, as with spiders, our Indian ants are not a real danger to man as are certain southern hemisphere species. Possibly the worst and least avoidable invertebrate menace was the danger of walking into a hanging wasps' nest when pushing through thick under-storey or secondary scrub. I did indeed do this on several occasions and eventually developed a dangerous allergy, so that wasps became for me an ever present anxiety and I had numerous near-misses.

Have you ever heard of anyone dying from snake bite in an Assam forest, or even receiving a serious bite? I have heard mythical tales of people being chased by hamadryads, but the fact that these tales do not end in disaster speaks for itself. During nine months in North Borneo (now Sabah) we saw more snakes in the forest than during the whole of our 14 years in Assam, and had five narrow escapes from poisonous bites whereas we had never been near to being bitten in Assam—as far as we knew!

One thinks of the plant kingdom as being harmless, and in Assam we were only bothered by a "nettle" (whose name I never knew) with glabrous leaves. Contact with these large but inconspicuous plants gave no immediate warning sting but for a week afterwards there was the most intense burning irritation without any visible skin reaction. I would very much like to know the mechanism of this. We were spared such horrors as the poison ivy of America or the poison-dripping tree of the Borneo forests. I keep an open mind on natural phenomena, and whilst accepting observed facts I find that the deduced cause is not always correct, so I was distinctly curious about this tree. The story went that a man could take shelter under it during a rain storm and would later develop a massive dermatitis and die. Eventually I saw one such case who was desquamating and ulcerating over his entire body surface—fortunately he was cured with modern drugs and good nursing. These things can happen from numerous causes, but he stated that he had in fact been caught in a storm beneath the suspected tree. I obtained a piece of the wood and rubbed it on my forearm, giving myself a blister and later a patch of dermatitis which remained for many months; and it was only then I realised that the itchy blisters around my ankles were caused by dead leaves from this same tree scuffed from the forest floor into my socks.

Looking back on our times in the forest I am sure we put ourselves in greatest danger by the quietness of our progress. We were both engrossed in our own pursuits—mainly butterflies for me and birds for my wife and did not talk much, and in any case did not make unnecessary noise in order to avoid disturbing the life around us. Our few real frights were indeed due to this cause, and I suppose we were fortunate never to round a bend and find ourselves facing a tiger, as happened to a friend. Of the larger animals the commonest and potentially the most dangerous was the elephant. It was a common experience to find ourselves close to or even in the midst of a feeding herd, when the danger would have been from a panic reaction if we had been discovered suddenly. Much more frightening, because of the lack of warning, was to be moving quietly through the forest and suddenly to realise that the stock-still shape not far ahead was a lone tusker: a dignified and unhurried retreat and avoidance of that sector of the forest for the rest of the day was sufficient on all but one memorable occasion. On the day in question we had gone with two friends and our dog for an evening walk down our nearest forest track. This was a time of day I usually avoided because myopes do not see well in the fading light, but there was always the chance of something unusual—there might be a crepuscular Hesperiid, and it was at dusk along this track that we had seen a peacock pheasant (*Polyplectron bicalcaratum*) displaying to his mate. We had turned towards home again when we realised that a large tusker was occupying the track—and we had no feasible alternative route back to the safety of the land rover. He appeared to be comfortably set to meditate there all night, so we tried shouting, which he gave no sign of hearing. Foolishly perhaps, but the light was rapidly going and we had a fair distance still to walk, we then lobbed stones onto the track near him, and this stimulated him into immediate action—in the wrong direction!—for he began to chase us. I have never had such a nightmare experience, and just as in a true nightmare my legs seemed to have turned to lead and refused to answer my will, but although they felt numb they carried me round the next few bends, by which time our pursuer had apparently lost interest and left the track. There remained the problem of what he was doing since he was by now perfectly silent. In any case we really had no alternative to returning quietly back towards the land rover—with further moments of panic when our dog slipped off to investigate in the bamboos.

Leopards were as rare as tigers were plentiful, and I always hoped that the latter would not be lying up too near human or game tracks or that their very keen senses would alert them before we had approached too close. We saw fresh tracks most days, but this was the closest we ever got while on foot. We were never on foot in buffalo country, but our second major fright was caused by walking into the middle of a herd of resting gaur. We were walking quietly along a game path through moderately high grass between a salt lick and the near-by river when there was an upheaval like an earthquake all around us—which ended before we fully realised what had happened, leaving us with a fleeting impression of the grass erupting with large dark, white-stockinged, forms. We could have wished for a more leisurely view, from a slightly safer distance, of the only herd of gaur in that part of Assam! (This was, in fact, an important encounter, since it had not been certain until then that the rumoured herd existed.)

The animals I have mentioned so far have all been creatures one would treat with respect because of their size and strength as compared with man, but the one which the older generation of tea planters warned us to avoid like a bogey was, curiously, the wild dog. It was said to be the most dangerous animal in Assam, invariably attacking man on sight and killing him by weight of numbers. This always seemed to us most unlikely. The literature did not support these stories, nor did contemporaries intimately familiar with forest life, such as E. P. Gee. His experience was the same as ours: on the few occasions when we met the wild dog face to face it was just as anxious to escape from the proximity of man as is any other forest animal.

The most potent cause of fear is the unknown: the crashing in the forest around you no longer causes panic when you *know* that it is nothing worse than elephants, which you have met many times before and with which you are familiar. Quite different are the noises one cannot place, and of these I can recall two very clearly. On the first occasion we were going up a yard wide dry nadi in heavily forested hills near Moreh on the Manipur-Burma border. Ahead of us we could hear something moving over the dry leaves, and then we realised that it was steadily approaching. By this time I had made a personal rule never to go back, whatever was heard in the surrounding forest—it would generally be harmless or minding its own business, but meanwhile, whatever was approaching us? There had been talk in the bazaar the previous evening about a tiger which had taken a cow—or could it be a bear? It grew ever larger in imagination as the noise of trampling on the dry leaves increased in volume, magnified explosively by the surrounding stillness and the narrow cleft in the hillside. Finally we stood still and awaited our fate—and a couple of otters bounded into view! On another occasion we were nearer home, walking along a small tributary of the Jhanzi River. In front of us there was a screen of thick bushes obscuring the approach to a large rock which ended a couple of feet from the stream. From the hillside above the bushes there was a ponderous tread coming slowly towards us—again it was the dry season and the hillside and the dead leaves exaggerated sounds. We froze, and waited for what seemed an age—to be rewarded by nothing more alarming than the snout of an outsize monitor lizard appearing past the rock on its way to the stream.

Of all the forest noises of our earlier years the two most characteristic were made by Man and his relations. The echoing call of the hoolock gave us a cheerful welcome on each visit to the forest, and in those days could often be heard from our bungalow. Man himself, in the form of parties of Nagas going to and from the local markets, made a sort of low-pitched antiphonal grunt with a remarkable carrying power. These parties of bare breasted loin cloth'd Nagas ceased after the start of the Naga War, just as the hoolocks became much scarcer at about the same time. Looking back, this was really the turning point of our life in Assam. For obvious reasons we could no longer obtain an inner line permit for the nearest hills, nor for the very exciting and relatively little known (in the natural history sense) Angami country around Jhakama and the high peaks of Japvo and Tentpo. We had numerous friends amongst the Nagas, some of whom turned up at my hospitals in moments of medical crisis, and I also employed most knowledgeable Ao and Angami collectors. Quite suddenly all this changed. The local Nagas no longer came to the plains bazaars, and any parties we met were likely to be armed and from the interior, neither side being quite at ease at these forest encounters. Perhaps we were foolish to continue our forest walks as before, but one has to take life as it comes. We knew there was no animus against us personally and that any harm would be accidental, and unlikely—although a party came down on one occasion with the intention of kidnapping the manager of the tea estate on which we lived, possibly as a hostage.

Wherever we have lived we have always seemed to be at the forest edge. We saw it retreating fast in Assam, and even faster in Borneo. Now here in England the fight continues for the small patches of woodland and downland, wetland and heath that yet remain "unimproved". May you in India be able to continue the magnificent work begun with Kaziranga, the Gir Forest and other specific sanctuaries, where individual species have already been saved from extinction, extending the principle of conservation now to whole ecosystems. Large areas of the old province of Assam call for this treatment before it is too late, and it would be a happy thought if the proposed enlargement of the Manas Reserve could be regarded as the first step towards such an extended reserve. This would indeed be a fitting tribute to our loved and distinguished past President, Dr. Sálim Ali, who more than any other person has made wildlife conservation respectable in India and India's achievements known and respected overseas, and to the late E. P. Gee to whom the same words equally apply, particularly in the context of Assam.

HOW MAN MODIFIES CLIMATE

ANNA MANI[1]

INTRODUCTION

Large forests, vast expanses of water and desert, and fertile soils are the products of the general climate of the earth over which man normally has no control. But man in the process of reshaping his environment has modified these features, by the destruction of forests over large areas, the conversion of arable land into pastures and agricultural tracts, the drainage of large swamps, the construction of large scale irrigation works, manipulation of surface and ground water, and urbanization and industrialization. Such activities have changed the physical and atmospheric environment and affected its suitability for human habitation and for agricultural pursuits. The question which arises is whether these activities of man have changed or will change the climate of the locality or the region or even perhaps the climate of the whole globe.

There is no doubt that whenever man changes the landscape he modifies the microclimate of the area. Winds, air temperature and humidity and soil moisture around a building or a ploughed field are different from those in its natural surroundings. In a city or town consisting of buildings, roads and paved areas, the local climate is quite different from that of surrounding areas. The effect or urbanization on local climate is well documented and the average changes in climatic parameters caused by urbanization has been given by Landsberg (1970) as follows:—

1. Contaminants	
(a) condensation nuclei and particles	10 times more
(b) gaseous admixtures	5 to 25 times more
2. Cloudiness	5 to 10 per cent more
3. Fog, winter	100 per cent less
4. Precipitation	5 to 10 per cent more
5. Relative Humidity	2 per cent more
6. Radiation, global solar	15 to 20 per cent less
7. Air Temperature, annual mean	0.5 to 1.0°C more
8. Windspeed, annual mean	20 to 30 per cent less
9. Sunshine duration	5 to 15 per cent less

These climatic changes are caused by the increased surface roughness, the changed albedo, the accelerated run off of water and the changed heat storage capacity in a city or town, resulting from the replacement of forest and fields by buildings and roads .But the influence of these processes does not extend significantly beyond the built-up areas.

MAN'S ACTIVITIES INFLUENCING CLIMATE

The climate of a locality is usually defined by the long term statistics of the variables that describe the weather at the locality, such as temperature, rainfall, cloudiness, winds and so on. Climate is conveniently represented by the mean values and the variances of these variables, provided such statistics are based on records for at least 30 years (SMIC, 1971).

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Man's activities which can modify climate are many. To the extent man destroys or conserves forests, pollutes air and water, alters the land surface and manipulates surface and ground water and improves or exhausts soil fertility he does control climatic factors locally. Thousand of years before the Industrial Revolution in the West and in countries where industrialization is yet to take place, agricultural and animal grazing practices have exercised a profound influence on large regions of the world.

Effect of deforestation

The earliest and most widespread modifications of the climate by man has thus been quite inadvertently achieved by the conversion of natural vegetation into arable land and pastures. During the last eight thousand years dense forests of the mountainous areas in Europe and Asia have been cut down to meet his agricultural needs. And the savannah grasslands of the tropics are entirely man-made. Increasing areas have been converted from steppe and forested steppe into arable land, and grazing by domestic animals especially goats have reduced parts of Africa and South West Asia to semi-deserts. In India the conversion of forests into arable land has predominated and now covers at least 10^7 square Km. In North West India an original steppe has been changed into a semidesert without any appreciable recent variation of precipitation. Bryson (1971) has argued that the Rajputana desert is man-made. Noting that the vertically integrated water vapour content is comparable with that over some tropical forest regions, he suggests that the tropospheric dust loading from the desert has increased atmospheric subsidence, this inhibiting precipitation. Archaeological and pollen studies indicate that the desert was relatively fertile several thousand years ago and that it contained a fresh water lake that supported an early civilization. Deserts are apparently spreading with speed of about 1 to 2 km per year depending on the density of the population.

The problem is equally acute in the Himalaya, Western Ghats and the Nilgiris, where the widespread use of wood for fuel and deforestation without adequate replanting has led to permanent damage to the landscape, water systems and normal patterns of run-off and caused widespread erosion. Vast areas of the Himalayan foothills have been stripped of forest and only fragments remain. The plains and lower hills are almost bare of vegetation of any kind. The only exception is in northern Assam where the problem is less severe on account of the smaller populations and the immensity of the rain forests. The natural cycle of precipitation, percolation, evaporation and transpiration have been disturbed by the drastic alteration of the vegetation cover, humidity and temperature of the Western Ghats and Nilgiris which play a vital ecological role affecting the climate and the water regime of a vital hinterland.

It is even more acute in the Andaman and Nicobar Islands, whose unique tropical rain forests are its richest natural endowment. The removal of forests in the tropics where there is considerable rainfall and where the vegetation depends for its existence on retaining the essential minerals in a relatively thin layer of humus can be disastrous. Surface run-off under nonforest conditions may often result in severe soil erosion and in flash floods downstream. The forests of the Andaman and Nicobar Islands are the only Indian forests that have escaped the withering effect of interference by man, fire and cattle till very recent times. The introduction of colonisation since independence had led to large-scale clearance of dense forests in the Andaman group of Islands and partly in the Nicobar group of Islands. Due to the peculiar geological strata, the sandy soils of the islands have no water holding capacity and drainage is very rapid. The extensive clearance of the dense forests would naturally result in severe soil erosion and expose the cleared areas to its ravages and transformation into grasslands or barren desert, after one or two growing seasons when the highly weathered soils are devoid of their ground cover and when the humus layer is washed away.

Tropical Rain forests are a non-renewable resource and the Government of India realising the importance of preserving this unique heritage, appointed a multidisciplinary committee to carry out a comprehensive land use capability survey and suggest measures to protect and conserve these forests for future generations. The Government also enforced a moratorium on forest felling for settlement or plantation agriculture in 1975. It is hoped that legislation action will be taken to ensure that substantial areas of the remaining virgin forests are set aside and regarded as inviolate and all offshore islands which have not suffered substantial interference through tree felling or settlement are declared as nature reserves.

We should mention here that the destruction of a rain forest is almost an irreversible process. Soil moisture is no longer retained and in addition the soil dries rapidly and may release clouds of dust into atmosphere changing the regional radiation balance.

Modification of the natural vegetation affects several significant climatic parameters, the surface roughness, the surface albedo and the apportionment of the available net radiation into sensible and latent heating of the atmosphere. In the Rajputana Desert formerly covered by vegetation, the ration of sensible to latent heat is 2.0 to 6.0, while it is about 0.3 over tropical jungles. Destruction of forests thus causes the replacement of large latent heat sources by large sensible heat sources and might have a significant effect on the generation and dissipation of tropical easterly waves. This deforestation might also affect the dynamics of the general circulation through a series of non-linear interactions (SMIC 1970).

Forests modify climate, not only in the area they occupy, but also around them. Within a forest, the air and soil mean temperature are lower, humidities higher, light intensities 50-90 per cent less and precipitation as much as 25% higher, evaporation 1/3 to 1/2 that in the open and winds 70-90% less depending on its penetration.

More than the actual effect in precipitation the effect on its destination by forests in greater. By breaking the violence of rain, increasing the absorptance capacity of the soil cover, preventing erosion and checking surface runoff, forests increase underground seepage in general. Forest soils have great water holding capacity and precipitation, which without the forest cover is rapidly disposed of by surface run off, is retained in the soil. The connection between forests and groundwater needs to be emphasized. Forests being much less compact than comparable grassland or open soils, it absorbs all available rainfall during the wet months and releases the water slowly during the dry months. The Famine Commission of 1880 had referred to many areas, where several streams which had been extant for decades had dried up, because of the cutting down of forests in surrounding regions. Forests may not increase total precipitation but certainly help to dispose of it more economically and more fruitfully than does land devoid of forest.

The influence of forests on local climate is best illustrated by shelter belts placed at right angles to prevailing winds, which reduce winds on both the wind and leeward sides, resulting in reduction of evaporation, lowering of temperature, increasing humidity and soil moisture.

Although statistical evidence on the effect of deforestation on climate is lacking, it has been observed that temperature is 1-2°C lower in the forest than over denuded areas, average wind speeds 7-10 times as great on denuded areas in winter and 30-40 times greater in summer and precipitation 17-18% greater. The climate differences except in precipitation can be attributed definitely to forest denudation.

The disastrous effects of floods have also been observed in two watersheds, one of which retains its protective cover and the other is burnt. Both watersheds had the same precipitation during one storm; while flood waters swept out of the burnt valley and through a town destroying 200 homes and taking 34 lives, in the unburnt valley, just a few kilometres away, the storm was easily handled by the existing channel and there was neither flood nor water damage.

Effect of air pollution

One of the most clearly evident influences of man on his environment is his direct contamination of the atmosphere, by injecting gaseous and solid affluents into the air. The increase in the particulate load of the atmosphere arises from both industrial activity, transportation and the burning of waste crops and vegetation, a practice in many tropical area for many thousands of year. Particles scatter and absorb solar radiation and also have an effect on the outgoing infrared radiation from the surface. So these man-made products will influence the heat balance over wide areas.

The primary contributions to atmospheric dust are soil and rock debris from the arid regions of the world, which have their greatest expanses in the mid-latitudes of the northern hemisphere. Man has played a part in creating this source of dust, particularly in the deserts of northern Africa and south west and central Asia. In India, measurements over the Rajasthan desert have shown the dust to extend to heights of 10 km over north and central India in summer and the particle concentration to be as high as 1200 $\mu g/cm.^3$ The dust was seen to be mostly silica or sand on analysis. Measurements of atmospheric turbidity at a number of stations in India during the last two decades have shown a two to four fold increase in the particulate load, particularly in more highly industrialised regions (Mani *et al.* 1971). A measurement of condensation nuclei and dust content have also shown a seven fold increase since 1930 (Mani & Huddar 1972) at Poona.

It is also well known that the carbon dioxide content of the global atmosphere has been rising due to the burning of fossil fuels such as coal, petroleum and natural gas and it is expected that it will go up by another 20% by 2000 A.D.

Surface transportation of people and foods contributes to the modification of the climate in two ways, first by emission into the atmosphere of particulate and gaseous exhaust products that can impact on radiation fields and precipitation and second by the modification of the reflective and thermal properties of the land surface by highways. The land surface covered by roads in a developed country such as the United States is 1% of the whole country, a not insignificant quantity.

Automobiles contribute approximately half of some air pollutants observed in US cities and the same is true of other industrialized countries. In India the number of automobiles is a small fraction of those in the West but the exhausts from vehicles on Indian roads are many times those of the automobiles in the West, where strict laws on exhaust control and air quality are enforced. Internal combustion engines are a major source of aerosols such as lead particles and of gaseous precursors of photo chemical smog.

Another rapidly escalating activity of man is air transportation, unique in that most of its products are injected directly into the atmosphere at levels well above the surface, in the high troposphere and the lower stratosphere. For the first time in the history of man, he can now put material directly into the stratosphere in the form of combustion products such as water vapour, nitrogen oxides and other gases and particles. The potential effects of supersonic aircraft on climate and on the ozone layer in the stratosphere which shields life from harmful ultraviolet radiation are well known. It has been estimated that commercial aviation will double its fuel consumption every five or six years in the next decade or so. With the expected increase in aircraft flights, we may expect at least a threefold increase in the pollution from aircraft by 1985. There are indications that jet traffic has already caused a small increase in cirrus cloudiness in heavily travelled areas and this will have a small effect on the heat balance of the atmosphere. Since the supersonic transports fly in a region where the average residence time of their exhaust products is one or two years, there is a chance for the concentration to build up.

The danger of injection of radioactive material into the stratosphere from nuclear explosions is equally great. With the enforcement of the nuclear test ban treaty there has fortunately been a decrease in the amount of radioactive debris in the stratosphere.

Another danger is that from the debris from hundreds of satellites that orbit the earth. This is comparatively less significant but likely to increase in future.

The chief pollutants that can react with atmospheric ozone and cause a reduction in the amount of ozone present in the stratosphere are oxides of nitrogen, chlorine and bromine as well as chlorofluoromethanes such as $CFCl_3$ and CF_2Cl_2. While the currently planned supersonic aircraft may not significantly affect the ozone layer, a large fleet of SST flying at greater altitudes will have a noticeable effect. So also the increased production of nitrous oxide at the surface by the increased use of agricultural fertilizers and of nitrogen fixing vegetation leading to an increase of NOx in the stratosphere and the increased release into the atmosphere of chlorofluoromethanes, leading to rapidly increasing amounts of CLOx in the atmosphere. Since the removal rate of CLOx concentration is very slow, the stratospheric CLOx will continue to increase for several years, even after all emissions of chlorofluoromethanes into the atmosphere ceases, due to the slow rate of difusion through the stratosphere. Thereafter, the recovery rate would be of the order of a few decades.

The possible destruction of ozone and the danger of increased solar ultraviolet radiation penetrating to the earth's surface and causing adverse biological effects on man, animals and crops and adverse climatological consequences has been a matter of great concern to everyone involved. Since solar ultraviolet is very strongly absorbed by ozone, the temperature of the stratosphere is largely maintained by a balance between absorption of solar radiation by ozone and emission of infrared radiation by ozone, carbondioxide and water vapour. Any change in the stratospheric heating rates will directly affect the temperature distribution in the stratosphere and possibly in the troposphere. And these temperature changes will effect the patterns of the general circulation and the weather and climate.

An average temperature decrease of up to 10°C in the upper stratosphere is expected to result from reduction of ozone due to man's activities. Calculations indicate the corresponding temperature change at ground level of only a fraction of a degree. Because of the complexity of stratosphere-troposphere interactions it is not possible to infer with any reliability what the full consequences will be on the earth's climate.

The potential threat of a considerable depletion of ozone having been established, the World Meteorological Organisation is now conducting an experiment for the continued long-term monitoring of ozone and other trace gases in the atmosphere, as well as ozone destroying radicals such as N_2O, chlorofluorothanes and other halogen compounds. By the end of the next decade we should be nearer finding scientifically sound answers to questions concerning the role of anthropogenic pollutants in reducing the quantity of ozone in the stratosphere and on the possible impact of changes in the stratospheric ozone content on climate.

Thermal pollution or the release of heat into the atmosphere from industrial, transportation and domestic sources, rivers, lakes and oceans is a matter of importance to be considered with the escalating demand by man for more and more power. With the doubling of the present world population by the year 2000 A.D., coupled with an expectation of more energy to be used per capita, the production of energy of all kinds will rise by a factor of five by 2000 A.D. There may eventually be industrialized zones extending for thousands of sq. km. the additional input of energy may equal the net radiation from the sun. The main effect of this heat input on the local scale is the creation of a stationary 3-dimensional heat island. The intensity of this heat island reaches a maximum at night time when the air temperature is a minimum, when the surrounding rural areas are cooling under the effect of the net outgoing radiation. The minimum intensity occurs shortly after noon when the sensible heat flux of the surrounding areas is more or less equal to the input of artificial heat. Under stable conditions with light winds the effect is restricted to a shallow atmospheric layer five hundred metres in thickness, the surface warming being of the order of 2 to 6°C. Measurements in Bangalore, Bombay and Poona have been shown the existence of such heat islands less intense in Bangalore (1-2°C) and most pronounced in Bombay (4-6°C).

Changes in climate due to alterations of the earth's surface

Man has been changing the landscape in many ways for thousands of years ever since the creation of a shepherd-farmer culture. His impact on the environment has been sometimes for the better as in the draining of swamps and often for the worse as by scarring the country side by urban and industrial sprawl and creating semideserts and arid regions by destructive agricultural practices and overgrazing by animals, and mining and drilling for oil and gas even in the oceans.

Urbanization and industrialization in principle influence the parameters determining climate although they are difficult to quantify at present. Any process that changes the heat balance of the atmosphere can influence climate at least locally and surface albedo changes, heat injection and material injection do just that. The changes in climatic parameters due to urbanization have already been listed in para 1.

Manipulation of surface and underground water

Another influence of man is his manipulation of the surface waters by building dams, creating lakes, draining swamps and directing rivers. River flows have become so regulated by the building of dams such as the High Aswan Dam on the Nile that the large annual flooding of the Nile delta has been reduced to a small fraction. Some of the lakes are so large such as Lake Nasser as to appear on maps of the world.

All this has its influence upon the atmosphere. Open water has an albedo substantially lower than that of other surfaces. It has a much greater heat capacity and it adds water vapour to the air. Both the amount and the seasonal distribution of absorbed solar heat can thus be changed by altering the area covered by water. Since the water surface may have a temperature quite different from that of land at the same location, the distribution of heat among longwave radiation, sensible heat and evaporation will be significantly different. This is particularly true of a water body in an otherwise arid area such as Lake Nasser in Egypt. In this case the heat absorbed by the surrounding dry area is indirectly used to increase evaporation. Downwind the water vapour content of the air is increased, creating effects on the radiation balance and eventually on precipitation itself. Measurements at Aswan have shown this is actually so, there being an increase in cloudiness and a decrease in solar radiation since the construction of the High Aswan Dam.

Another process modifying climate is irrigation. Much of the irrigation water evaporates and the 1700 km^3/ year of nonreturned irrigation water represents a change of about 5 per cent in the run-off of the land areas and 2 per cent of the total annual evaporation of land areas.

The direct influence of the energy used for evaporation of irrigation water is to speed the hydrological cycle. All the heat used in evaporation is returned to the atmosphere where condensation occurs. Apart from local effects which are large, the global climatological impact will depend on such indirect influences as changes in cloud cover and resulting effects on the radiation balance.

One indirect effect is quite significant. An irrigated area grows vegetation that has an albedo significantly lower than the ground cover it has replaced. The interesting consequence is that while the local temperature is lowered by irrigation because of the increased evaporation, global temperature is raised because of the decreased reflection of incoming solar radiation. Budyko (1971) has calculated that present day irrigation leads to an increase of earth's mean surface temperature by 0.07°C.

With the estimated five fold increase in irrigation, industry, energy production and waterworks, the amount of evaporating water will be three times higher. The total effect of irrigation on global albedo and the effect of man's activities on the hydrological cycle must be expected to increase substantially.

Another important by product of man's activities is the effect of mining underground or fossil water that has accumulated in climatic eras when there was more precipitation than now. For example agriculture in Sahara is made possible by tapping subterranean reservoirs of fossil ground water preserved to a large extent from the last ice age with a radio carbon age of 20,000 to 25,000 years. The fossil water below the Rajasthan desert has been carbon dated to be 8000 years old. The observed drop of twenty to thirty metres of the groundwater level in Gujarat and Tamil Nadu in the last decade can only interpreted as a consequence of the overexploitation of the ground water and the increasing imbalance of the actual water budget caused by the exploitation of fossil water reserves at a faster rate than can be replenished under present climate conditions. The groundwater stored in the pores and fractures of soil and rock constitute about 5% of the total free water in the world and at the rate at which this essentially irreplaceable source of water is consumed and salt water moves in to replace fresh water along sea coasts, man is changing the natural balance of the earth, though not necessarily its climate.

WEATHER MODIFICATION

Sustained weather modification in seeding clouds with freezing nuclei such as silver iodide crystals or salt particles will change the climate over a period of time, but there is no general agreement of the success in attempts in many countries including India to modify the weather. There is no doubt that seeding can modify clouds but whether it increases precipitation depends on many factors. Artificially induced rain might largely evaporate leading to an intensification of the exchange rate in the hydrological cycle. Or most of it may run off, resulting in a redistribution rather than net increase in rainfall.

Hail suppression experiments in the USSR and Switzerland have been considered to be a success as well as fog dissipation trials elsewhere. Such experiments and efforts at control of cyclones or hurricanes will offer man the opportunity to exert a considerable influence on climate. All such measures must be carried out with great care and with consideration for more than local and immediate effects. Considering the military uses to which weather modifications has been put in the past, the United Nations have recently passed a resolution which precludes the use of weather as a weapon of war.

The World Meteorological Organisation, a specialized agency of the United Nations has organised Precipitation Enhancement project which is expected to serve as a rallying point for the scientific efforts in weather modification.

CONCLUSION

There can be little doubt that man in the process of reshaping his environment in many ways has changed the climate of large regions of the earth and he has probably had some influence on the global climate as well, exactly how much it is we do not yet know. While we do not know how to predict man's impact on climate, the distinct possibility that it could occur as a result of man's activities warrants every effort to understand the mechanisms that govern climate and climatic change. (Kellogg 1975).

Considering the profound implications of climate modification, the World Meteorological Organisation has organised a Climate Dynamics programme for the study and understanding of the physical basis of climate. While the ability to predict natural fluctuations of climate is valuable, a knowledge of the longterm climatic effects due to human activities may well be even more important since human activities are perturbing the atmosphere in ways which have no analogue in the earth's history. The programme will include enhanced global observations of key physical qualities and increased intensive efforts at climate modelling and numerical experimentation, with the hope that we shall be thus nearer an understanding of the fluctuations of climate and the response of climate to the increasing inadvertent influence of mankind on the environment.

"Samudra Mekhale devi parvatha sthana
mandale pada sparsam Kshmaswa me"

"Oh Mother Earth, girdled by the oceans and the mountains, pardon me for trespassing on you"

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RECENT ADVANCES IN INLAND AQUACULTURE IN INDIA

V. G. JHINGRAN[1]

(*With five plates*)

The inland aquaculture resources of India are estimated as 1.6 million ha of freshwater ponds and tanks, 2.0 million ha of brackish-water lagoons and impoundments, 0.72 million ha of natural lakes and 2.0 million ha of man-made reservoirs. India is perhaps one of the few countries in the world which have vast inland aquaculture resources. Unfortunately, a significant part of this potential resource is unutilized and even the part that is in use is under-utilized. The contribution of inland fish production in India is about 40% of the total fish production of the country, of which at least 50% is contributed by aquaculture resources alone. It is unfortunately not realised that the potentials of aquaculture resources are so great that, if properly developed and exploited, these could contribute 15 to 16 times more than their present yield. In the following pages I outline some of the important achievements in inland aquaculture in India in the last few years.

1. Fry/fingerling production

The first research programme undertaken after independence was increasing the survival rate of spawn and fry of cultivable carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) during their nursing. The mortality rate of spawn in nursery ponds was as high as 97% which was almost reversed as a result of detailed researches conducted at the Central Inland Fisheries Research Institute and a survival of about 50% made easily possible under field conditions with the application of the newly developed techniques. Further improvements have been effected in the technology in recent years. The rate of stocking in nursery ponds initially was 1 million spawn/ha which has now been increased to ten times, i.e. 10 million/ha. The concept of well-manured, predator—and weed-free, nurseries, with abundance of natural fish food (zooplankters) which is simultaneously supplemented by protein rich organic feed of vegetable origin, has been developed. Great emphasis is now laid on the water quality (pH, DO, ammonia, alkalinity, phosphates and nitrates). Despite such a high rate of stocking, a survival of over 66% is possible with the addition of cobalt (0.01 mg/fish/day) in the feed. This technological development enables production of a very large number of fry/unit area which is especially advantageous in view of the paucity of nursery space in the country.

Similarly, the development of a three-tier system of culture, i.e. growing the fry obtained from nursery into another set of ponds called rearing ponds, before finally stocking them in larger water sheets for production of table-sized fish has proved itself to be greatly advantageous in handling the young ones and increasing survival rates. Fingerling rearing techniques have been developed and a survival of over 80% is now obtained in such operations when the stocking density is as high as 350,000 fry/ha. A 3-month rearing gives a crop of fingerlings which in terms of weight is of the order of 3,000 kg/ha, each individual fish growing to 100-150 mm which is a suitable size for stocking larger sheets of water. A survival of over 90% from well-prepared stock ponds can be expected in all cases where large-sized fingerlings are stocked.

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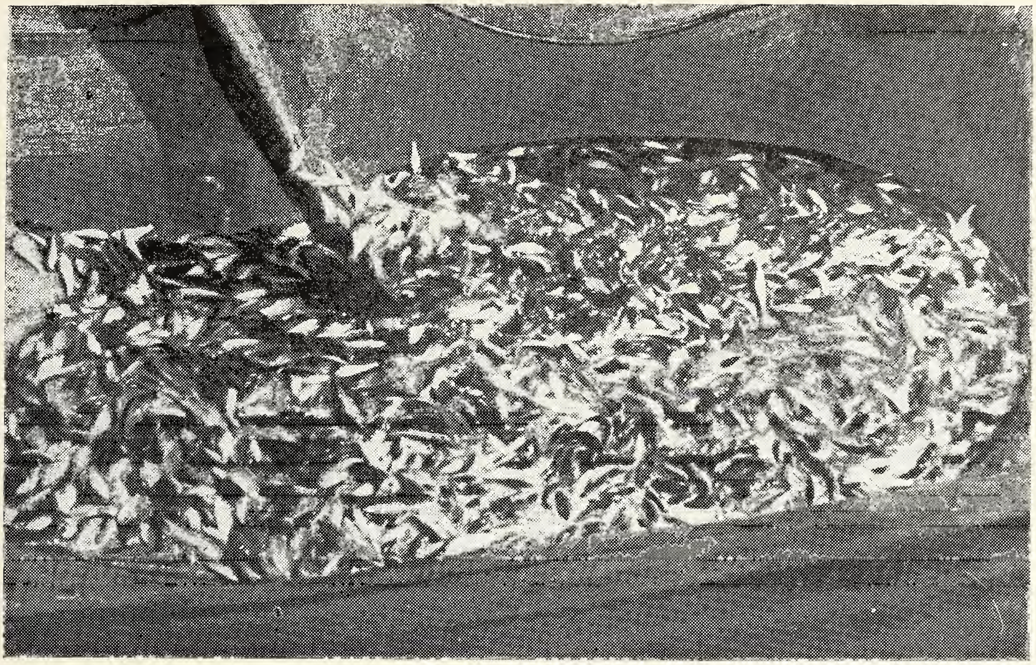
2. **Pond preparation**

Considerable work had to be done during the course of rearing experiments on developing the techniques of pond preparation and fertilization. As the import of derris-root powder, which was used as a fish toxicant for eradication of predatory and weed fishes at the research farms, was stopped, the need to find a suitable indigenously available substitute was felt. A large number of plant toxins were screened and the root and bark of *Barringtonia acutangula*, seed of *Milletia pachycarpa* and *M. piscida*, and *Croton tiglium* found quite effective. However, non-availability of these products on a commercial scale resulted in the popularisation of the use of mahua oilcake (*Bassia latifolia*), despite its requirement in large quantities as an efficient piscicide at 2,500 kg/ha-meter and a longer detoxifying period. The fish killed by the application of mahua oilcake is fit for human consumption unlike certain chemical piscicides. Ammonia (15 ppm N) too is an effective piscicide, weedicide and a nitrogenous fertiliser.

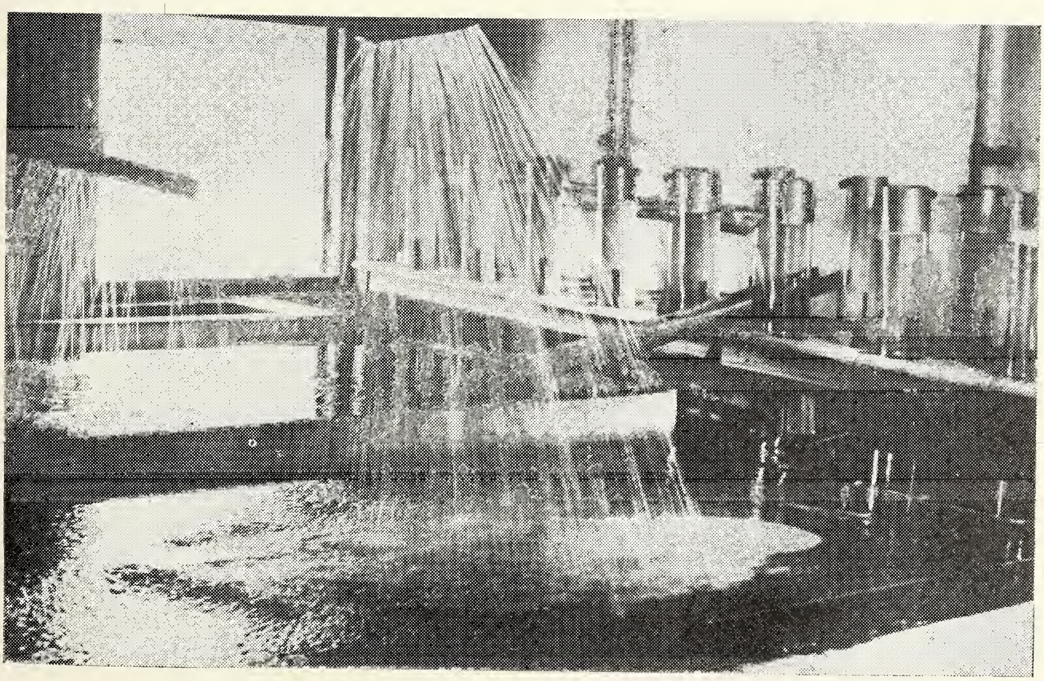
Studies on the effect of various types of organic and inorganic fertilizers and their dosages indicated that an application of universally available cowdung at 10,000 - 20,000 kg/ha results in an abundant growth of fish food organisms in nursery, rearing and stock ponds. In acid soils, this application is preceded by treatment with lime at 300 kg/ha. Use of poultry manure has been found to be very effective and much smaller quantities than cowdung constitute an effective dose. In recent years, utilization of inorganic fertilisers has also found a place in pond preparation. Urea for slightly acidic to neutral and ammonium sulphate for alkaline soils are suggested for pond preparation. Calcium-ammonium nitrate is another suitable fertiliser for acid soils which provides both calcium and nitrogen at the same time. For stock ponds, liming followed by an initial high dose of cowdung (5,000-10,000 kg/ha) or mahua oilcake (2,500 kg/ha-m) followed subsequently by alternate application of inorganic and organic fertilisers every month is generally recommended in systematic freshwater carp culture.

3. **Fish breeding**

The cultivable carps of India namely catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) breed annually in flooded rivers and contiguous fields during the monsoon months. Naturally, these resources therefore constitute the collection grounds for the young ones of these species. Natural collections from the rivers and flooded fields are but a mixture of both desirable and undesirable species of fish as most of the predatory and weed fishes also breed during the same season. This results not only in wastage during collection but also during subsequent handling, rearing and transport where the undesirable fish seed is either responsible for large-scale predation or competition for food, space and oxygen. It was, therefore, necessary to develop a technique whereby the cultivable carps could be bred exclusively for their seed and at will. The practice of breeding these fishes at will by creating semi-natural conditions is already known for a long time in certain districts of Bengal and Bihar. This technique,



A haul of fingerlings.



Glass Jar hatchery.
(*Photos*: Author)

Bumper catch from a composite fish culture Pond.

Haul of healthy magur fed on dried marine trash fish.
(*Photos*: Author)

known as *bundh* breeding, has now been considerably improved and extended to various parts of the country.

However, of the two types of *bundhs,* wet and dry depending upon the availability of water either throughout or a part of the year, the dry type yield better quality seed and are more dependable than the wet ones. The general unsuitability of the site and construction, maintenance and operation costs have been the main impediments in the multiplication of *dry* bundhs in seed production. The technique, wherever possible, is certainly advantageous for mass production of fish seed and has also been successfully used for experimental spawning of the Chinese major carps (grass carp and silver carp) which are now in great demand in India.

An important landmark in the history of freshwater aquaculture research and development has been the spawning of cultivable fishes by administration of fish pituitary gonadotropins known as induced breeding or hypophysation. The technique of induced breeding was first developed in India in 1955 and not only the indigenous carps but also the exotic carps as well as several species of catfishes, air-breathing fishes and mullets can now be spawned within a 2 × 1 × 1 m box-like cloth chamber, *hapa,* fixed half or three-fourths submerged in water. Mature males and females when injected with the pituitary gland extract, ovulate and spermiate either naturally or by application of gentle pressure on the abdomen of the brood fish after a lapse of a few hours of injection. The dosages for the different species have been standardised and the technique is increasingly being used for the production of fish seed for aquaculture in the country.

The techniques for hatching the eggs were also very poor and generally resulted in heavy mortality. However, the use of double-walled cloth *hapas* (the outer one of muslin cloth and the inner one of round-meshed mosquito netting) which is a sort of an open box within a box, has helped in increasing the hatching and the survival rate of the young hatchlings. Yet another development during the last five years has largely done away with the vagaries of nature as the *hapas* have to be fixed in ponds where high temperatures, heavy winds or fluctuating water levels, algal blooms, crabs and trash fish, generally create havoc resulting in mass mortalities or poor survival. The new technique makes use of continuously running water through a series of glass jars, where the eggs are kept, virtually buoyant, and provided with sufficient aeration. The hatchlings, drifting out through the jar spout on to an open conduit, are collected in a separate receptacle where again a continuous shower provides adequate aeration. Since the glass jar hatchery is put on land under a shed, the field hazards to which *hapas* are exposed are largely done away with as also the recurring expenditure on cloth *hapas* which hardly last a season.

4. Composite fish culture

Considerable attention has been paid in recent years to increase the per hectare production of table fish from stock ponds. Experiments in this direction conducted from the early sixties initially gave productions of 3,000-4,000 kg/ha/yr. However, in course of time further experimentation resulted in higher and higher rates of fish production so much so that production as high as over 9,000 kg/ha/yr was obtained in experimental ponds. This technology involving the use of indigenous (*C. catla, L. rohita* and *C. mrigala*) and exotic (*Ctenopharyngodon idella, Hypophthalmichthys molitrix* and *Cyprinus carpio*) major carps coupled with a set of management practice is termed as composite fish culture. Stocking densities from 3,000 to 10,000 fingerlings/ha have been used and densities around 5,000 to 7,500 fingerlings/ha found easily manageable. As in the case of nursery and rearing ponds, the concept of well-manured, predator-free ponds with a natural abundance of fish food organisms is also the rule in composite fish culture. In order to achieve high productions, periodic fertilisation of the ponds and daily feeding of fish with supplementary food items like groundnut oilcake and rice bran (1 : 1) at 2-3% of the body weight of the fish stock is necessary. The various species stocked in the pond are so proportioned that the natural food is utilised without much competition between the different species. These proportions have been carefully worked out in the course of a decade of experimentation. Surface feeders (catla and silver carp) constitute about 35%, followed by mid-feeders (rohu and grass carp) which account for about 30%. The bottom feeders (mrigal and common carp) constitute another 35%. Since silver carp feeds on the primary producers (phytoplankton) which are always in a greater abundance than the secondary producers (zooplankton), a higher percentage of silver carp (25%) than catla (10%) is stocked in a pond. Of the mid-feeders, rohu browses on a wide variety of planktonic algae and organic debris and constitutes 20% of the stock as against grass carp which forms 10% of the total density. As grass carp can be raised on aquatic or land weeds resulting in economy of supplementary feed, a variety of aquatic or land vegetation, cattle fodder and various vegetable wastes, are provided in a floating enclosure in the pond for its consumption. Supplementary feed in the form of a dough is provided on feeding trays, hung ½ to 1 m below the water surface, only after the grass carp are satiated. The bottom feeders, mrigal (15%) and common carp (20%), obtain their natural feed from the bottom detritus, decaying organic matter and semi-digested faecal matter passed out by the voraciously feeding grass carp. The unutilised faecal matter of grass carp acts as a fertiliser. This synergistic equation is the crux of composite fish culture.

5. Domestic sewage/livestock wastes as fish pond fertilisers

The practice of utilising domestic sewage for fertilising fish ponds is in vogue in several parts of the world and also in India around Calcutta for a very long time. Domestic wastes are available in every village, town and city. They pose a great problem in large cities and are discharged into the river courses which they pollute causing considerable damage to the total aquatic life in general and fishes in particular. Use of this waste is aptly made by its introduction, either as such in the raw form, or after dilution or as a supernatant effluent after initial settlement, in large ponds. This is one of the cheapest and the richest fertiliser for fish ponds. Alternately, fish ponds afford one of the simplest and cheapest means of abating pollution due to domestic sewage. The wastes are recycled in ponds and high quality fish protein obtained. Rates of fish production are also high without the use of supplementary feed in this system of culture. Productions as high as 9,350 kg/ha/yr of *Tilapia mossambica* have been obtained from ponds irrigated by sewage effluents. A production of 7,200 kg/ha/yr has been obtained by carp culture in these ponds. A very high stocking density is also possible because of the abundance of the natural fish food organisms and their repeated regeneration. However, oxygen deficiency and high BOD occasionally cause a havoc resulting in mass mortality in such ponds. Diseases due to parasites are also a common feature. One has, therefore, to be extremely careful while utilising sewage effluents for fish ponds.

Use of cattle / poultry / duckery / piggery wastes is also made in fish ponds. However, the techniques for their use are not yet standardised in India and attempts in this direction are being made at the Central Inland Fisheries Research Institute. Preliminary results on the use of wastes from pig-sties and duck-houses have resulted in high fish production without fertilization and feeding. This has a great future for India as the feed costs in composite fish culture account for about 50% of the total expenditure.

6. New systems of culture

Some catfishes and air-breathing fishes are in great demand in certain parts of India. However, there has been no systematic culture of these species until recently. Early attempts made to culture murrels (*Channa* sp.) resulted in a failure. In recent years, attempts to develop a new system of culture—air-breathing fish culture/catfish culture—have been made. The important air-breathing species such as singhi (*Heteropneustes fossilis*), magur (*Clarias batrachus*) and murrels (sal, saul and lata, *Channa* sp.) are now being cultured in swamps, derelict waters, freshwater ponds and cages in both swamps and freshwater ponds. As the air-breathing species can withstand poor oxygen conditions swamps and derelict waters can be conveniently used for their culture. This is just one way of utilising the abandoned waters in the country. The techniques of mass breeding the air-breathing species by hypophysation have been perfected and the dosages utilising the carp pituitary for the purpose standardised. The difficulties in hatching and rearing the young ones have also been surmounted by use of nylon *hapas* which prevent the entry of macroscopic planktonic forms known to be preying on tiny hatchlings while, at the same time, allowing a free exchange of water. Supplementation both by choice food organisms and artificial feed comprising boiled egg powder further helps in increasing the survival rate of the young ones.

The greatest difficulty experienced in the past while culturing these either carnivorous or piscivorous species was the provision of large quantities of living organisms or fishes throughout the year in culture ponds. This has been solved outright by providing a diet of dry, marine trash fish to the fingerlings of these species on which they feed avidly and grow well and fast. A production of 5,000 kg/ha/5 months of magur and 4,042 kg/ha/7 months of sal (*Channa marulius*) has been obtained under the new systems of culture in swampy and derelict ponds. Magur and singhi have also been cultured in freshwater ponds in combination with carps or without them. A production of 1,200 kg of magur/ha/4½ months was obtained from a small shallow pond under carp culture, the contribution of carps being 2,108 kg/ha/9½ months.

Cage culture of singhi and lata (*C. punctatus*) has also been done and a production of 9 kg/m^2/7 months and 5.2 kg/m^2/6 months respectively has been obtained. The fish in these cages have been fed on a mixture of cowdung + silkworm pupae + oilcake. Cage culture of singhi in carp ponds and magur culture in ponds with water changing facilities are presently being experimented with for high yields.

7. Control of aquatic weeds and their recycling

Of the four methods of weed clearance *viz.*

manual, mechanical, chemical and biological, biological methods are the cheapest. A weed-eating fish of Chinese origin *viz.* grass carp (*Ctenopharyngodon idella*) was introduced in India in 1957 along with a planktivorous fish *viz.* silver carp (*Hypophthalmichthys molitrix*) for biological control of higher aquatic weeds and algal blooms respectively. While it has been possible to control submerged and floating weeds of various types by introduction of grass carp in various water sheets, silver carp has not proved useful in the control of algal blooms in fish ponds. A lepidopteran insect larva (*Erastroides curvifascia*) has been recently discovered to be a potent biological control agent for the effective control of the floating weed, *Pistia stratiotes.*

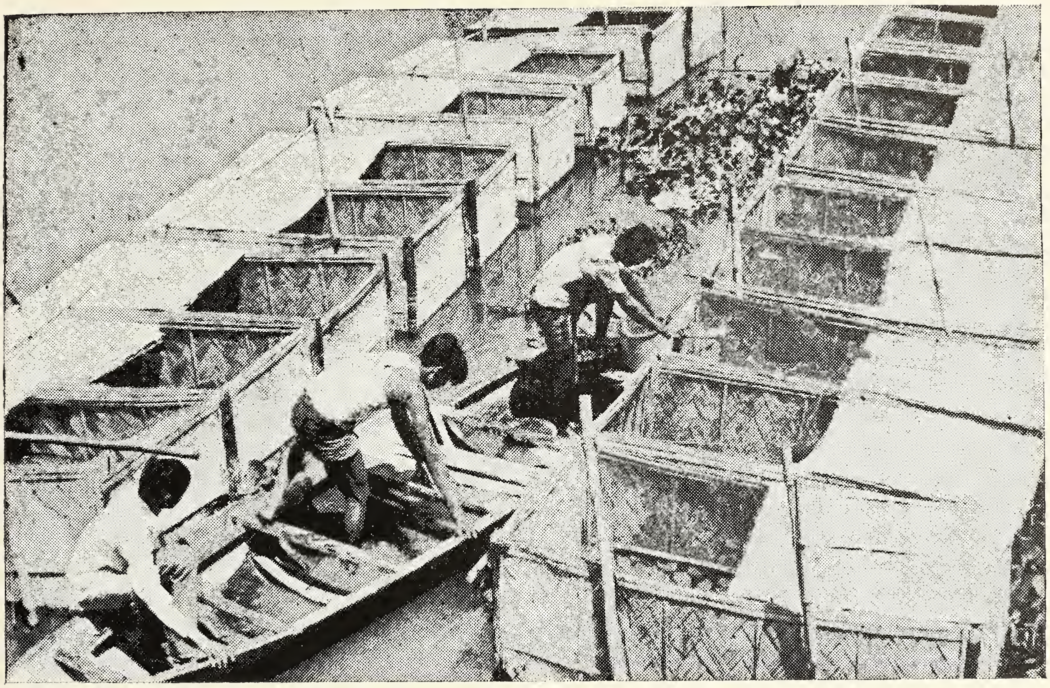
Manual methods of weed clearance are the cheapest and perhaps the best for small water bodies but for larger water sheets and dense infestations, mechanical or chemical methods are necessary. Mechanical methods have been tried in India and several types of weed harvesters developed but the initial high cost coupled with subsequent operational costs have hindered the popularisation of these mechanical devices. Chemical methods thus remain the only solution. Several chemicals have been tried in the course of the last 25 years and effective methods of controlling the noxious floating and emergent weeds like *Eichhornia crassipes. Nymphaea* spp., *Ipomoea carnea, Pistia stratiotes, Cyperus* sp. by use of sodium salt of 2, 4-D without any adverse effect on fish or fish food organisms developed. Aqueous ammonia is equally effective in controlling the submerged weeds. However, use of sodium arsenite, copper sulphate and simazine, though effective, is not generally recommended as it results in gradual accumulation of toxic ions in aquatic animals and proves harmful to human beings in the long run.

8. **Culture of fish food organisms**

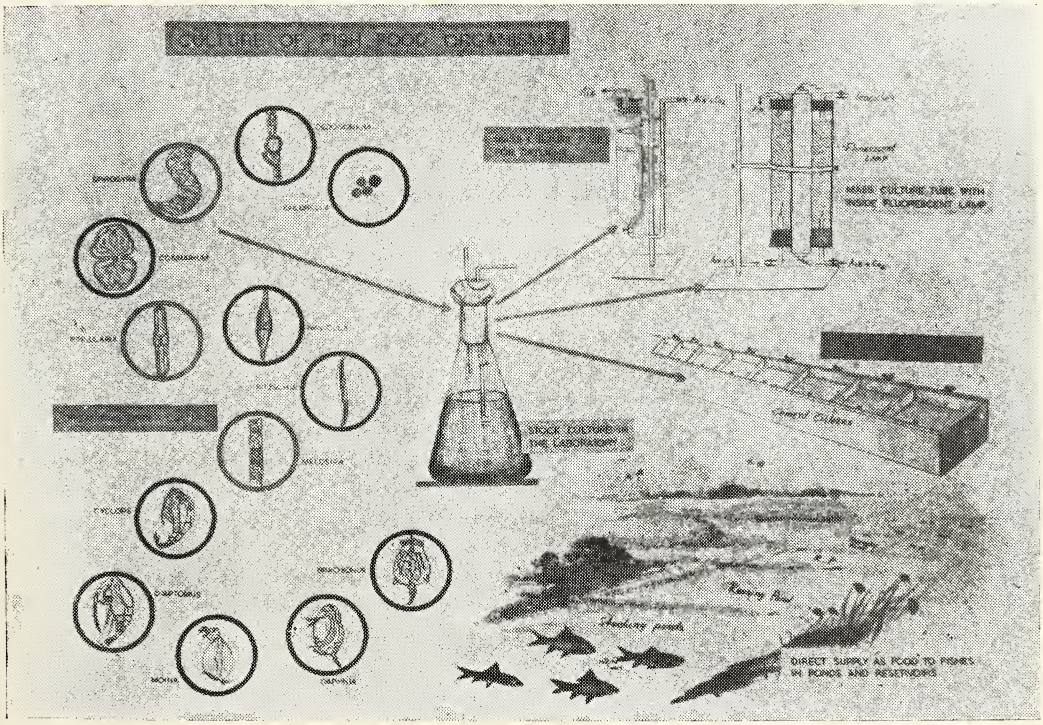
In ponds, fertilisation offers a means of increasing the abundance of fish food organisms. This, however, is a laborious, time consuming and expensive process and may not always result in the abundance of required organisms. Moreover, excessive fertilisation might also cause blooms which are detrimental to fish life in culture ponds. Large scale culture of choice food organisms is, therefore, necessary in a separate environment wherefrom they could be collected and fed to the growing fish. Mass culture of *Chlorella vulgaris* and *Daphnia similis* has been done and a simple and inexpensive method developed using inorganic fertilisers and poultry manure as nutrient source. Freshly-cultured *Chlorella* is used as food for *Daphnia similis.* Mass culture of *Navicula cryptocephala, N. rynocephala* and *Pinnularia acrosphaeria* is done in polythene bags containing water fertilised with urea, single superphosphate and sodium silicate. Culture of *Moina dubia* and *Daphnia lumholtzi* has also been done. It is hoped that this development would result in establishing natural fish food farms.

9. **Freshwater prawn rearing**

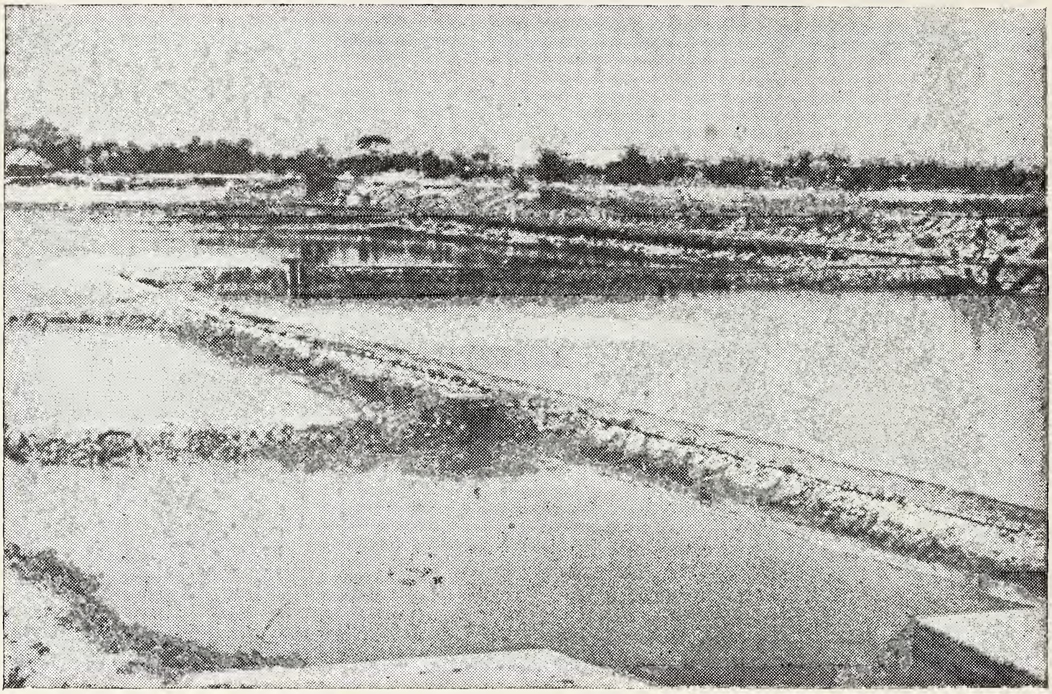
The two important species of freshwater prawns *viz. Macrobrachium rosenbergii* and *M. malcolmsonii* have not yet been systematically cultured in India despite their immense export and domestic market. Both *M. malcolsonii* and *M. rosenbergii* can now be bred in a confined environment. *M. rosenbergii* has recently been bred and reared through its larval stages in the laboratory. The young prawns so produced were reared in ponds at 5,650/ha and a production of 284 kg/ha/4 months obtained. Experiments on propagation and culture of *M. malcolmsonii* at Badampudi



Cage culture has a great future.


CULTURE OF FISH FOOD ORGANISMS
MASS CULTURE TUBE WITH INSIDE FLUORESCENT LAMP
STOCK CULTURE IN THE LABORATORY
CYCLOPS
DIRECT SUPPLY AS FOOD TO FISHES IN PONDS AND RESERVOIRS

A beginning in the establishment of fish food farms.
(*Photos*: Author)



A view of the Brackish water fish farm, Kakdwip (West Bengal).

Selective stocking of mullet pays high dividends.
(*Photos*: Author)

(Andhra Pradesh) and Cuttack (Orissa) have been in progress for some time past. *M. malcolmsonii*, stocked at 50,000 and 75,000/ha has given a production of 212 to 314 kg/ha and 94 to 270 kg/ha respectively in $10\frac{1}{2}$ months. The survival rate has been very poor being 7 to 51%. At Cuttack, however, net productions have ranged from 285-380 kg/ha/yr when stocked at a density of 20,000 juveniles/ha. Attempts are also being made to rear and culture *M. birmanicum* var. *choprai* which is available in considerable abundance in some streams draining into river Ganga in Bihar and Uttar Pradesh.

10. Coldwater fish culture

Not much attention was paid in the past towards the development of hill-streams and upland lakes in India except in a few cases where trouts were introduced either in late last, or early present century. Mirror carp, introduced in certain regions, has well established itself in the lakes but its large-scale propagation for food still remains to be achieved. Establishment of commercial trout farms in the upland areas would not only provide a highly delicious fish to the people of the region but also sport at the same time. This aspect could also be utilised for promotion of tourism and as a source of foreign exchange.

The survival of trout through its various stages of life history was, until recently, very low in the farms of Himachal Pradesh and Kashmir. Experiments conducted on determining causes of mortality have led to the development of techniques for obtaining higher survival. Hatchery practices have now been standardised and the survival from green egg to swim-up fry stage increased to about 89%. Malachite green, used as a fungicide in hatching troughs, results in increasing the survival rate greatly. The mortality in fingerling trout was found to be mainly due to poor feed. Experiments with compound and pelletised artificial feeds, with different levels of crude protein (28-39%), gave a high production and survival rate. A conversion ratio of 1.4 with feed containing 35-39% crude protein and 1.7 with 35% crude protein was noted in rainbow and brown trout respectively. Breeding of brown trout in Uttar Kashi (Uttar Pradesh) was taken up recently and an overall percentage of survival from green egg to fry stage of about 58% achieved. Ensuring high survival rates through use of modern techniques and highly nutritive feed would result in making trout culture a lucrative proposition in the uplands of India. Techniques for breeding and rearing the mirror carp, which result in higher survival rates, have also been developed.

11. Dangers of pesticide pollution

Pisciculture may be treated as an adjunct to agriculture. Large-scale use of pesticides in agriculture is likely to affect fish life in ponds and tanks, beels and jheels and also in rivers/estuaries. The latter form the main source of fish seed of freshwater and brackishwater species. Bio-assay studies on pesticides such as Gammexane, DDT, Folidol, ethyl parathion, Endrin, malathion and Rogor have been conducted using freshwater fishes, zooplankters (rotiger, copepods and cladocerans) and benthic organisms (oligochaetes, chironomids, gastropods and bivalves) as test animals. Investigations on pesticide pollution have indicated that DDT is one of the most dangerous pesticides which gradually accumulates in the body of the fish and even in sublethal concentrations is likely to affect human beings in the long run. The fish itself may die when the accumulated concentrations become lethal. It has to be seen to that while intensive cultivation using high yielding cereal varieties involving application of fertilizers and pesticides continues, fish culture is not adversely affected by the use of chemicals in agriculture. Judicious choice and use of pesticides would help find a solution to the problem. Aquaculture is to be treated as much a national activity as agriculture.

.. .. BRACKISHWATER AQUACULTURE

In brackishwater, fish culture technology has not made the strides in India as in the case of freshwaters though there exists a traditional system of brackishwater fish and prawn culture.

1. Fish and prawn seed resources

Until recently, there did not exist a trade in brackishwater fish or prawn seed. Numerous seed collection centres have been located in Hooghly, Rupnarayan and Matlah estuaries and Chilka and Pulicat Lakes and in the vicinity of Brackishwater Fish Farms in a few States. Investigations on artificial induction of spawning in mullets (*M. cephalus* and *Liza macrolepis*) have been made and experimental success attained. *M. cephalus* could be spawned in brackishwater and the induced-bred spawn reared in the laboratory. At least two specimens could be reared for varying periods—one for 150 days (72 mm/6 g) and the other for 325 days (100 mm/12 g)—for the first time in India. It is expected that techniques of hatching and rearing mullets in confinement would be soon understood and a breakthrough in brackishwater fish farming in India soon achieved.

2. Culture of mullets

Mullets being the most important species of brackishwater fishes, techniques of raising them in ponds have been given utmost attention. Techniques of nursery rearing of *L. parsia* and *L. tade* have been developed. Monoculture of *L. parsia,* mixed culture of mullets and polyculture of mullets and prawns have been tried. A production 2,400 kg/ha/yr has been obtained in monoculture of *L. parsia.* In a six-species combination of prawns and mullets (*P. monodon, P. indicus* and *M. monoceros* and *L. parsia, L. tade* and *M. cephalus*) a net production of 2,617 kg/ha/yr has been achieved.

3. Prawn culture

Brackishwater prawns (*P. indicus, P. monodon* and *Metapenaeus* spp.) have a great export market. Rearing techniques of *P. monodon* and *P. indicus* have been evolved and detailed methodology for the culture of *P. monodon* developed. While three short-term (100-120 days) crops of *P. monodon* have been obtained giving a total production of 1,055 kg/ha in 320 days, attempts to raise four crops by shortening the period of each crop to 90 days have been made. A production of 305 kg/ha/90 days was obtained in the first rearing. Long-term (320 days) rearing of *P. monodon* results both in lower production (872 kg/ha) and poor survival rates though in larger sizes. Polyculture of *P. monodon* and *P. indicus* and chanos, *L. tade* and *L. parsia* gave a production of 2,580 kg/ha/9 months and *P. indicus* and chanos gave a production of 1,396 kg/ha/6 months.

4. Culture of fish food organisms

A breakthrough has been achieved in laboratory culture of *Artemia salina* which needs to be imported for rearing the larval stages of prawns and several species of brackishwater fishes. Sustained culture of brine shrimp has been possible in field conditions at water temperatures of 26 + 2°C and a salinity of

35 ppt. Sun-dried eggs have been preserved for future use.

Mass culture of certain phytoplankters (*Gyrosigma angulatum, Nitzschia closterium* and *Navicula lanceolata*) has also been done.

FUTURE PROGRAMMES IN AQUACULTURE

1. **Culture of *Hilsa ilisha***

Hilsa is an important fish both from the point of view of taste and market demand. It contributed sizeably to the fisheries of Indian rivers and estuaries but the catches have been dwindling for the last many years due to dam contruction on the rivers. Experiments on artificial propagation of hilsa conducted with a view to stock the rivers with the juvenile fish, though begun early in the present century, were not very successful. However, in recent years, a new concept has developed that besides stocking the rivers, the fish could also be cultured in freshwater ponds. With this end in view, induced propagation of hilsa was initiated in the mid-sixties and it was possible to strip, fertilise and hatch the eggs and rear the spawn in nurseries in 1968. The fish could even be reared in ponds for over two years. Though the growth was slow but the possibility of rearing the fish has been indicated by these experiments. It is necessary that the techniques of breeding, hatching and rearing are soon developed to make these valuable fish available to the consumers.

2. **Statistical and economical evaluation of cultural operations**

Both agriculture and animal husbandry have advanced greatly as the experiments in the related fields have been statistically designed and economically evaluated. Paucity of a large number of ponds has been the major hinderance in experimentation on statistically based designs in aquaculture. Aquaculture scientists in India had to remain contented with the meagre facilities that have been available to them. To help solve this problem a large 150 ha Fish Farm is being constructed at Dhauli (near Bhubaneswar) in Orissa where experiments based on statistical designs on all aspects of freshwater fish culture will be conducted. This farm will not only be useful from the point of finding out a scientific basis for the various results but also in conducting experiments on several aspects of aquaculture which have not been handled properly so far.

In order to be acceptable to the entrepreneurs, the profitability of fish culture operations together with detailed analysis of the costs involved needs to be demonstrated. A beginning in certain aspects of freshwater aquaculture has already been made which needs to be intensified in the coming years. Economic evaluation of methods of spawn production by various sources such as riverine, *bundh* breeding and induced breeding has been done and it has been concluded that though spawn produced through *bundhs* and induced breeding costs more when compared to riverine collection, the production strategy needs to be planned in the context of regional aquaculture development programme as a comparison of spawn production economics on a countrywide basis may be misleading. Detailed analysis has been done in respect of the cost structure of the experiments on the new technology of composite fish culture. The per hectare expenditure has been found to be the maximum (Rs. 15,067/-) in the western region (Maharashtra and Haryana) and the minimum (Rs. 6,904/-) in the southern region (Tamil Nadu and Andhra Pradesh). The cost of fish production, however, has not been found to vary greatly, being Rs. 2.38 in the central region, Rs. 2.67 in the southern region, Rs. 2.73 in the western region and Rs. 2.93 in the eastern region. The feed costs constitute the major share of expenditure (50-60%) followed by labour costs. A study of composite fish culture undertaken by fish farmers in West Bengal indicated that the index of untapped yield reservoir from freshwater fish culture source alone is of the order of 4.4 and the average production could be raised by 450% through adoption of the new technology of composite fish culture. The average gross profit per hectare of culturable water area has been found to be as high as Rs. 16,000/- at current price structure.

3. **Fish diseases**

High density, mono- or poly-culture of fin fish and/or shell-fish, is bound to create problems of fish diseases which may even assume epidemic proportions at times. Fish parasites in freshwater and brackishwater fishes have been studied in India for a long time but fish diseases have been studied only from freshwater ponds. Treatment methods in respect of several of these have been developed but research efforts need to be intensified to understand the various bacterial and viral diseases which are likely to be encountered in future.

4. **Fish nutrition**

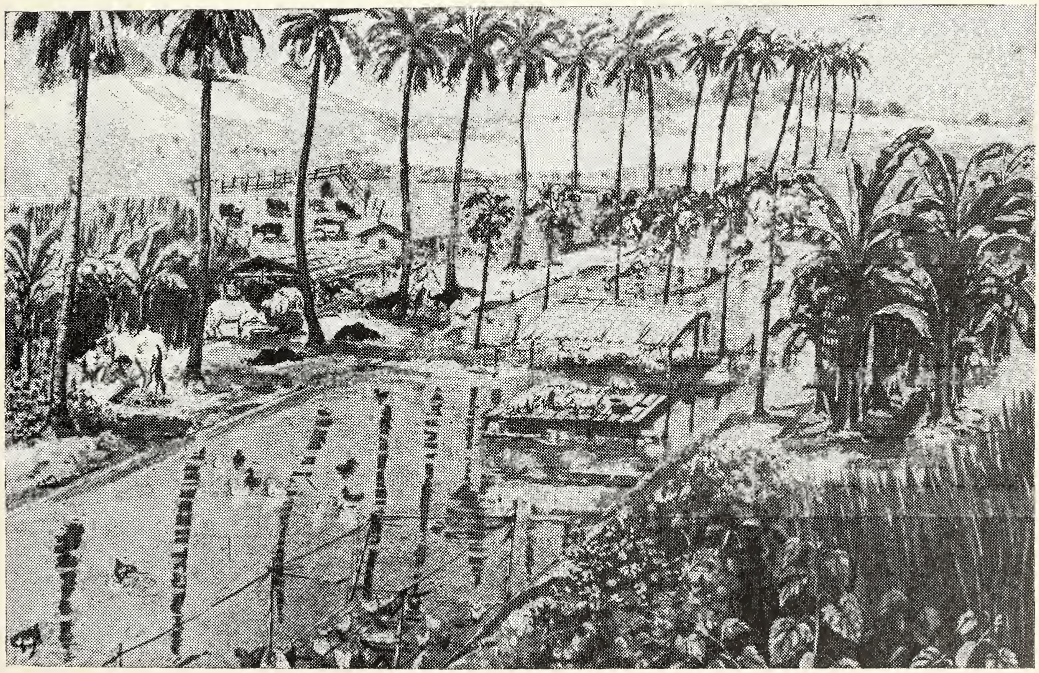
Oil cakes and brans (wheat and rice) constitute the traditional items of fish feed in India. While certain combinations of these items are used to feed the fish both in freshwater and brackishwater aquaculture in association with, at times, some animal waste products, these have, strictly speaking, no scientific basis. Nutritional studies on the cultivable species of fish need to be conducted and their requirements in different stages of growth, during different seasons of the year and at different temperatures made known to enable formulation of well-balanced, pelletised feeds.

5. **Fish genetics**

The role of genetics in agriculture and animal husbandry and its contributions in increasing the crop, milk, egg and meat production is well known. Fish genetics is so far undeveloped. It is time that the genetic basis of various culture systems of fin-fish and shell-fish is understood, selective breeding and hybridisation conducted to improve seed production and fish yields in fresh and brackish-water aquaculture.

Despite all shortcomings, aquacultural developments in India have been sufficiently great during the past few years especially in carp culture and it has put us on the threshold of fish revolution or "aquaplosion". With the application of improved aquaculture technology, both in fresh and brackishwaters. India can hope to produce over 6 million tonnes of fish from aquaculture alone as against its estimated total requirements of 8.5 million tonnes (see table below). It is not difficult to obtain an average production of 4,000 kg/ha/yr from freshwater fish culture ponds. A production of 500 kg/ha/yr can be easily obtained from the swamps and derelict ponds. Though the present status of brackishwater technology is not very high, a production of 1,000 kg/ha/yr of fish and prawns is not impossible. Aquaculture alone can thus contribute 74% of the fish-protein requirement of the country.

Penaeus monodon has great export market potential.



Schematic representation of rural aquaculture using agricultural and animal wastes, providing quality protein and gainful employment.
(*Photos*: Author)

PRODUCTION POTENTIAL

System of culture	Resources available	Minimum yield with improved technology	Total production (in m tonnes)
1	2	3	4
Carp culture	1 m ha	4 tonnes/ha	4
Air-breathing Fish Culture	0.6 m ha	0.5 tonnes/ha	0.3
Brackishwater Fish Farming	2 m ha	1 ton/ha	2
Reservoir Fisheries	2 m ha	25 kg/ha	0.05
TOTAL :	5.6 m ha		6.35

A COMPARATIVE FIELD STUDY OF THE INDIAN AND NEW ZEALAND REPRESENTATIVES OF THE GENUS *RUPPIA* LINNAEUS

CHARLES MCCANN[1]

(*With three plates and three text-figures*)

INTRODUCTION

Botanists frequently encounter difficulty on determining aquatic plants as the original descriptions are often based on dried herbarium material with the essential characters distorted. The delicate floral structures do not lend themselves to 'resurrection', sufficiently to ensure accurate description. Again, figures made from such material leave much to be desired, more so if the artist lacks botanical knowledge. *Ruppia* as often defined and figured in some works is a good example.

Ruppia presents some ecological phases in the course of its development or growth in response to the habitat. In specimens under strong tidal influence (e.g. *R. maritima*), the extent of variation is often well defined according to the length of dessication due to exposure between tides, and the vegetation it is associated with (such as algae or some of the higher plants). *Ruppia* makes a poor herbarium specimen; its delicate membranes fracture too readily. One of the main difficulties with the genus appears, to me, to be the correct interpretation of the floral organs. This opinion I expressed in my previous paper (McCann 1945) on the Indian species. The floral organs are, at times, regarded as individual florets or, at times, as hermaphrodite flowers. This aspect will be discussed in fuller detail below.

In India, I had the opportunity of studying the Indian species (*R. rostellata*) in the field, over several seasons: it was to be met with in most of the salt-works. The results of these observations were published, together with a plate in this *Journal* in 1945. However, in that paper I erroneously referred the Indian species to *R. maritima* Linn.—it is *R. rostellata* Koch.

In New Zealand, I spent some time observing the species occurring in the lower part of the North Island. This plant differed in many respects from its Indian counterpart, markedly in the prolongation of the spiral twisting of the peduncle. This species I concluded was the *R. maritima* Linn. of the temperate regions.

RUPPIACEAE Linnaeus

Ruppia is the only genus in the family and is included in the Order Potamogetonales. The family and generic type is *R. maritima* Linn. (1753). Distribution "Europae maritimis." [Linn. 1753].

There is a difference of opinion among systematists as to whether there is a single cosmopolitan species or several geographial variations of a single species—or more than one species. My own observations satisfy me that there is definitely more than one species. This view is supported by the morphological and ecological differences between *R. mariti-*

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ma Linn. and *R. rostellata* Koch, but it is doubtful if more than the two exist.

Before proceeding, it is important to clarify some morphological points:

a) whether the floral elements (anthers and pistils) are to be regarded as two clusters, representing *two flowers* on the peduncle, or b) as *individual, unisexual florets* arranged in two clusters. After much observation of both species (*R. maritima* and *R. rostellata*) in the field, I have adopted the view that the whole is an inflorescence composed of two clusters of stamens and pistils alone arranged as individual florets on a common peduncle. This view appears to be supported by the differential maturation of the individual elements in both clusters.

In neither of the species discussed (*maritima* and *rostellata*) have I observed the development of more than two clusters to each peduncle, one on the opposite face to the other.

The next point of interest is the development of the peduncle. In *R. rostellata,* the peduncle is short, seldom exceeding more than 7-9 mm.; it never becomes spirally twisted. In *R. maritima* on the other hand, the peduncle ultimately attains a length of 100 mm becoming spirally twisted in the process of elongation, functioning like a 'spring' to carry the floral elements up or down in response to the variation in the depth and movement of the water. This difference in contortion of the peduncle in the two species may be partly due to the nature of the habitat and partly accounted for by the mode of pollination and fertilization between the two. The points will be referred to below.

Post (1883) stresses the difference in the length of the peduncle and its contortion between the two species (*maritima* and *rostellata*, noting that in the former (*R. spiralis* of Post) the peduncle is spirally twisted but *not* in *R. rostellata.* Cooke (1908) on the other hand remarks that the peduncle may be "strait or coiled" in *rostellata.* This view is untenable.

Peduncle:

The formation of the spiral peduncle in *Ruppia maritima* is apparently similar, superficially, to that of the female flower of *Vallisneria,* but in reality the spirality is achieved in very dissimilar ways. In *R. maritima* as the peduncle elongates beyond the leaf-sheaths, the position of the two floral clusters plays a very important role, for, the oppositely situated clusters rotate on the peduncle thus bringing about the twist of the spiral. The behaviour of the peduncle in this manner, not only brings about the formation of the spiral, but assists in the pollination of the florets at or near the surface of the water. This point will be referred to below.

In *Vallisneria* each female flower is solitary on a spirally formed pedicle which forms into a spiral before the flower matures. It uncoils on maturation of the flower and raises it to the surface of the water for a brief period, but on pollination the pedicle re-coils, taking the ovary to the bottom to fructify. The male flowers are clustered on a short (non elongating) peduncle and when mature, the sheaths open and the individual flowers rise to the surface as round 'balls'. At the surface they open and drift raft-like till an anther is 'trapped' by one of the 'Venuses-flytrap-like stigmatic divisions.

Before proceeding, it is perhaps worth examining some of the conflicting statements met with in some authoratative works:

Post (1883):

"Flowers 2, perfect, in a spike, at first enclosed in sheaths of floral leaves."

[*R. maritima* & *rostellata*].

Gray (1876):

"Flowers perfect, 2 or more approximated on a slender spadix, which is at first enclosed in the sheathing, spathe-like base of the leaf, entirely destitute of floral envelops, consisting of 2 sessile stamens, each with 2 large and separate anther-cells and 4 small sessile ovaries with a single campylotropus suspended ovule: stigma sessile, depressed.***" [*R. maritima*].

Cooke (1908):

"Flowers minute, hermaphrodite, 2-6 together within a leafsheath on an ultimately elongating strait or coiled peduncle. Perianth O. Stamens 2, anthers sessile, 2-celled. Carpals 4; ovules solitary in each carpal, pendulous; stigma peltate. Fruit of 4 stipitate ovoid obtuse or beaked achenes.***" [*R. rostellata*].

Cheeseman (1925—Oliver ed.)

"Flowers 2-6 together, at first completely enclosed in the inflated leaf-sheath; but the spike generally emerges and is borne up to the surface of the water by the usually conspicuously spirally coiled peduncle." [*R. maritima*]

Black (Blake) [South Australian Flora]

"Flowers bisexual, naked, 2 on opposite faces of the spike; anthers 2, sessile, 2 celled, pollen globular; carpels at first sessile, but becoming pedicellate as the ripen and carried to the surface of the water on a long spirally coiled peduncle." [*R. maritima*].

Johnson (1931)

"The flowers are borne at the surface of the water, but after pollination they are drawn beneath the surface by the curling of the stems." [*R. maritima*].

The spirality of the peduncle is not wholly in accord with the definitions of some of the authors and needs some explanation. To commence with, the spiral is developed only in *R. maritima*. The twist may be dextrorse or sinistrorse or yet again both turns may be present in the same peduncle! *Ruppia* the spiralling of the peduncle functions:

(a) as a protection for the inflorescence in the rapidly changing and boisterous habitat—tidal influence and wind.

(b) as a means of rotating the two clusters on the opposite sides of the peduncle and exposing the stigma to a chance of pollination.

I shall refer to pollination under a separate head.

Ruppia Linnaeus, Sp. Plant. (1753):127-128.

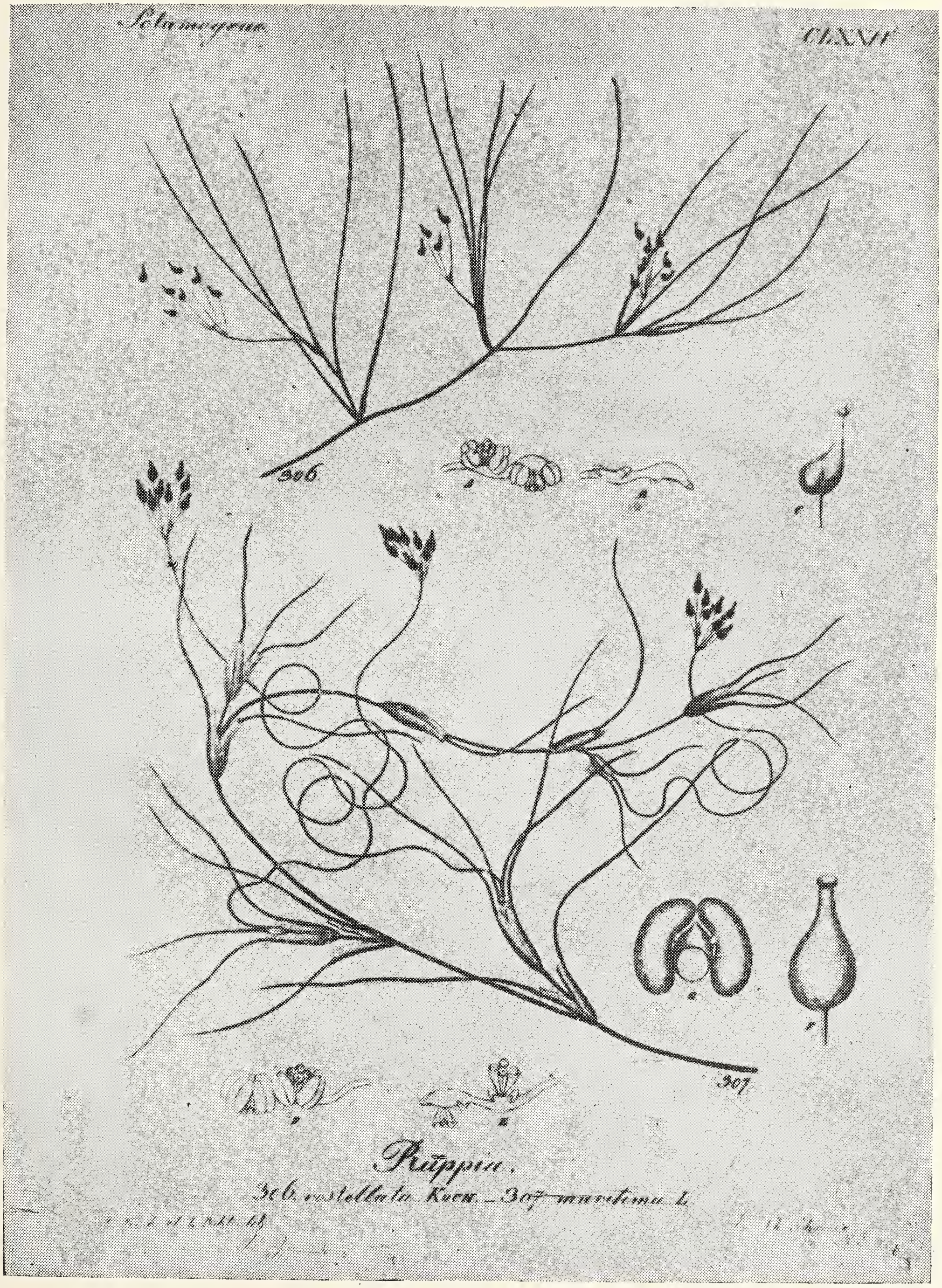
1 RUPPIA *Hort. cliff.* 436. *It. wgoth.* 186. *Guett. stamp.* 2. p. 416.

Buccaferrea maritima, foliis acutissimis. *Mich. gen.* 72, *t.* 35. Potamogeton maritimum, gramineis longioribus foliis, fructu fere umbellato. *Raj. angl.* 3. *p.* 134. *t.* 6. f. 1.

Fucus folliculaceus, foeniculi folio longiore. *Banb. pin.* 365. *Habitat in* Europae *maritimis.*"

Britton (1908)

"Flowers on a capillary spadix-like peduncle, naked, consisting of 2 sessile anthers each with two large separate sacs attached by the beaks to the peduncle, having between them several pistilate flowers in 2 sets on opposite sides of the rachis, the whole cluster at first enclosed in the sheathing base of the leaf. Stigmas sessile peltate. Fruit a small obliquely pointed drupe, several in each cluster and pedicelled.**** In the development of the plants, the staminate flowers drop off and the peduncle elongates, bearing the pistilate flowers in two clusters at the end, but after fertilization it coils up and the fruit is drawn below the surface of the water." [Gen. heading]. [*R. maritima*].


Potamogeae
CLXXIV
306
307
Ruppia.
306. rostellata Koch. – 307 maritima L.

Reproduction of Reichenbach Plate CLXXIV (1824)
306 *Ruppia rostellata* Koch, 307 *Ruppia maritima* Linn.

KEY TO THE SPECIES

R. maritima L.	*R. rostellata* Koch.
♀ florets 2-8	♀ florets normally 4 only.
Anthers 4, sausage shaped, encircling the peduncle.	Anthers 4, subglobose, not encircling the peduncle.
Peduncle spirally coiling to maturity; 90 to 100 mm.	Peduncle short, straight, not elongating nor spirally coiling, 7 to 9 mm.
Stigma semihemispheric.	Stigma peltate.

[*C. McCann*].

Ruppia maritima Linn. (Pl. I. fig. 307; Pl. III)

The marked difference in the shape of the anthers between these two species was drawn attention to by Post (1883). "1. *R. maritima* (L. sp. 184). antheranum succulis oblongis. fructibus ovatis oblique erectus. In fossis et paludosis at maris littora, (am Adriat. mere d. Ost.-W. Nordsee, in Fiirstenth. Güttingen in Denkenhäuser Sumpfe.) Aug. in autumn."

1753. *Ruppia maritima* Linn. sp. Plant.
1824. *Ruppia maritima* Koch in Reichb. Icon. Pl. Crit. 2:66; t. 174, fig. 306.
1827. *Ruppia spiralis* Dumortier [Florula Belgica: operis majoris prodromus. Tornaci Nerviorum (Tournai, Belgium). J. Casterman, 1827, p. 164.]
1853. *Ruppia* Hooker, J. D., Fl. N. Zelandiae I.
1862. *Ruppia maritima* Bentham, G. & Hooker, D. H., Gen. Plant., p. 1014.
1864. *Ruppia* Grisenbach, A.H.R. Fl. Br. W. Ind. Isl. p. 89.
1875. *Ruppia* Eichlep, A. W. Bluthendiagramme.
1876. *Ruppia maritima* Gray, Man. Bot.: Bot N. U.S. (Amer.) 5th ed. 8th issue, p. 484.
1878. *Ruppia maritima* Bentham, G., Fl. Australensis, VII:174.
1883. *Ruppia spiralis* Post, G. E., Fla. Syria, Palestine and Sinai. p. 824.
1904. *Ruppia maritima* Rendle, Classif. Flg. Plants, Pt. 1:204.
1905. *Ruppia maritima* Britton, N. L., Man. Fl. N. States & Canada, p. 49.
1908. *Ruppia maritima* Fitch & Smith, Ill. Brit. Fl. p. 231; ill. 957.
1925. *Ruppia maritima* Cheeseman, Man. N. Zeal. Flora 2nd ed., Oliver, p. 129.
1931. *Ruppia* Johnson, A. M., Tax. Flg. Plants, p. 617, Veg. N. Zeal. p. 61, 2nd. ed.
1928. *Ruppia maritima* Cockayne, Die Vegetation der Erde xiv.
1942. *Ruppia maritima* Oliver, W. R. B., Rec. Dom. (Nat.) Mus. 1:10.
1950. *Ruppia spiralis* Mason, R. Post-prim. Schl. Bull. 4(12); 240, pl. 8.
1967. *Ruppia polycarpa* Mason, R., N. Zeal. Journ. Bot. 524: fig. 1, A. and fig. 2.
1967. *Ruppia megacarpa* Mason, R., N. Zeal. Journ. Bot., 525: fig. 1 B, and fig. 3.
1970. *Ruppia polycarpa* Moore, L., and Edgar, E., N. Zeal. Fla. ii: 14. figs.
1970. *Ruppia megacarpa* Moore, L. B. and Edgar, E., N. Zeal. Fla. ii: 15, figs.
1971. *Ruppia spiralis* Adams, J. S., Wildlife—a review, 3:23-25.

Description from a fresh specimen:

A flexuose aquatic plant forming tangled masses beneath the surface of the water, the extremities floating at the surface: stem slender, filiform, 60 to 90 cm, leafy, except for the lowest portions, much branched; intermodes 80 to 90 mm, shorter below; each of the lowest nodes producing paired filiform, root hairs well developed. Leaves opposite or subopposite sheathing in the lower portion with an involute lamina, ligulate, reaching 30 cm long, sheathing base 3.5 to 4.5 mm. In floresence 5 to 7 by 2.5 mm excluding peduncle); peduncle 9-10 cm when mature; florets arranged in two clusters on opposite sides of the peduncle near its extremity: each cluster composed of 4 male florets and 8 (9) female florets reduced to large sessile or subsessile, sausage-shaped 2-celled anthers embracing the peduncle; pollen lunate, with large granular contents, buoyant. Female florets reduces to naked pistils, on very short pedicles (stipe) elongating after fertilization, stipes reaching 12 to 20 mm; ovary somewhat urceolate, surmounted by a dense globular stigmatic canopy; canopy furrowed and depressed towards the centre, margined by a thick lip. Achene 2.5 by 1.5 mm, obliquely ovate, beaked, mounted on the elongate stipe, black when mature. [C. McC.]

Note: This description is based on plants collected at Waikanae, New Zealand, 6.12.1947 and fresher material at the same locality and at Lake Ferry, N. Zeal., 1974-1975.

Ruppia rostellata Koch. (Pl. II).

1824. *Ruppia rostellata* Koch, ex Riechenb. Icon. Plant. Crit. 2 (1824): 66; t. 174, fig. 306.
1851. *Ruppia* ———— Griffiths, Notulae Plantes Asiaticas Pl. iii: 196-203.
1851. *Ruppia* ———— Griffiths, Icon. Plant. Asiaticas, Pt. III, pls. CCLVII-CCLIX.
1883. *Ruppia rostellata* Post, G. E. Fla. Syria, Palestine and Sinai: 824.
1893. *Ruppia rostellata* Hooker, J. D., Fla. Brit. Ind. VI: 568.
1908. *Ruppia rostellata* Cooke, Fla. Bom. Pres. 2:839.
1939. *Ruppia* McCann, C., The Flamingo: Journ. Bom. Nat. Hist. Soc., 41:12-38.
1945. *Ruppia maritima* McCann (per errorum) C., Notes on the Genus *Ruppia* (Ruppiaceae), 45 (3): 396-402.

"2. *R. rostellata* (Koch in Reichenb. Ic. 2, p. 66, fig. 306) antheranum sacculis subglobosis, fructus semilunari-ovatis e base obtusa ad scendentibus. In fossis litora maris et ad salinas, (an d. Ostsee in bei Arten in magdab.) Aug.-Autum. *R. maritima* DD. Fl. p. 861. Robliqua G. F. Meyer, MSpt. *R. rostellata* chlor. hanor. p. 527."

Description from fresh specimen:

A submerged aquatic herb growing in brackish water, forming dense masses of filiform, leafy stems and branches, 15 to 75 cm. long. Roots 20 to 70 mm arising in opposite pairs at the nodes of the stolons and lower branches. Stem a stoloniferous rhizome, dichotomously branched; internoded 45 to 50 mm; nodes slightly dilated. Leaves 70 to 90 mm, filiform with hyaline sheathing bases, ligule present, lamina involute. Flowers, minute, arranged in two clusters, one on either side of the peduncle, each cluster composed to 2 male and 4 female florets, reduced to anthers and pistils; peduncle 4 to 5 mm, elongating 7 to 9 mm in fruit. Male floret represented by 2 one-celled anthers on a very short filament, anthers suborbicular dehiscing through the middle; pollen long-reniform, buoyant, pale yellow, exhibiting large granules within. Female florets 4 in each cluster, reduced to pistils, stipitate, stipe elongating to 25 to 30 mm when mature, obovate-oblong, truncate, surmounted by a dense discoid, peltate stigmatic canopy; stigma mammilate, to one side, tinged with light pink; ovule solitary. Fruit ovoid, obliquely-ovoid or subreniform achene compressed, beaked; pericarp subcartilaginous, green, endocarp hard, black, bearing barbs and excrescences. Seed solitary testa membraneous. [C. McC.]

Note: This description is based on plants collected at Mira Road, Salsette Island, Bombay.

COMMENTS

Stem:

There is no remarkable difference in the character of the stem between the two species (*R. maritima* and *R. rostellata*) that I can discern. The stem is stoloniferous; in dense sandy loam the internodes are frequently short but in more open sandy conditions the internodes reach approximately 25 mm. Older stolons become quite wiry (*maritima*). Two roots appear at each node; one only frequently surviving. Root hairs are well-developed.

Leaves:

A pair of subopposite leaves is developed at each node; each leaf is composed of a hyalinely margined sheath separated from the involuted lamina by a hyaline, truncate ligule (figure M). The "two parallel tubes" of Cooke (1908). The paired sheath at each node overlap to form a "capsule" within which the early stages of the inflorescence is undergone and sheltered (figure N). Gases given off by transpiration (?) and growth appear to escape between the opposing "funnel-forming" ligules. These "capsules" appear to remain viable, long after the breaking off of the fragments from the parent plant; in this way they not only appear to protect the young floral elements, but are also capable of establishing themselves in fresh habitats, by the production of new roots at the nodes thus assisting, by drift, in the wider distribution of the species. In this "capsular" form the plants are often capable of withstanding the inclemencies of the weather, and rigours of winter, if not too severe and re-establish themselves afresh in spring, by propagation by adventitious shoots seeds and embedded stolons. (obs. *R. maritima*). A narrow hyaline or sheath bract subtends the peduncle.

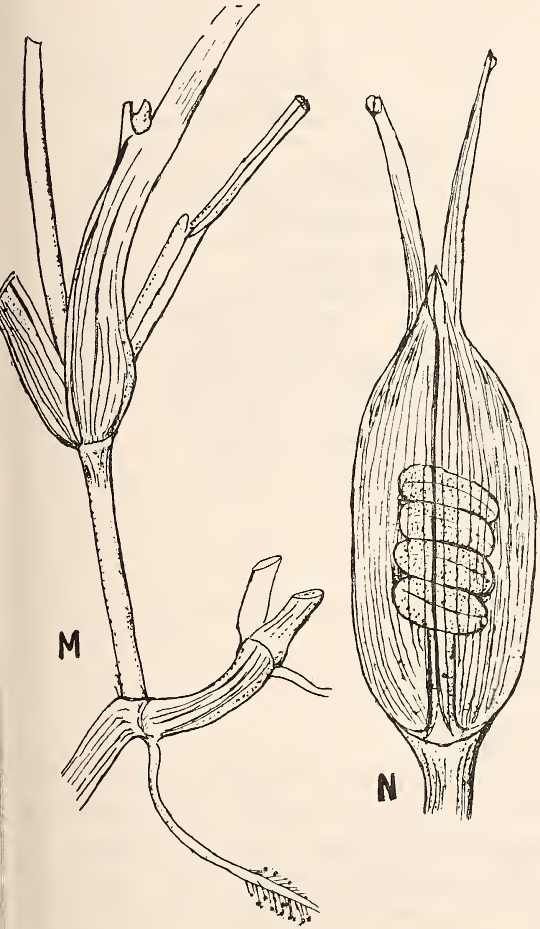


Fig. M. Rhizome and branch (note ligule); Fig. N. Leaf sheaths forming "capsule".

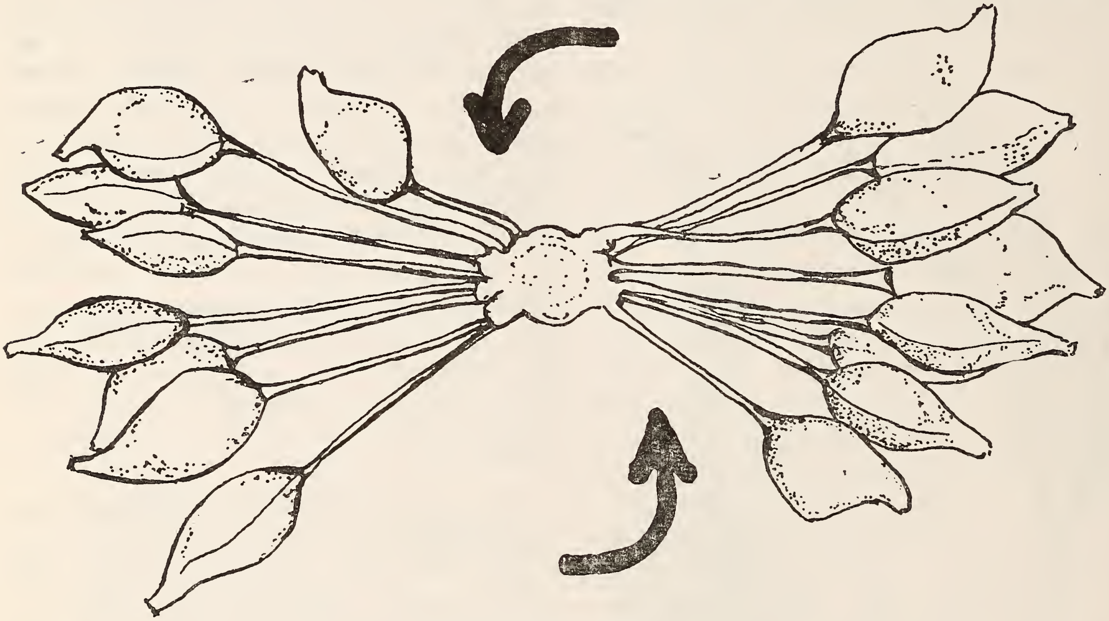
Flowers:

In this paper I regard the anthers and pistils as individual, unisexual florets arranged in two groups on a short (*rostellata*) or long (*maritima*) peduncle according to the species. In both species there are four anthers in each cluster, but they are differently arranged. In *R. maritima* each anther almost completely encircles the axis of the peduncle, like a tier of flat cakes (fig. N.) whereas in *R. rostellata* each anther is supported on the shoulder of a short ligulate filament in pairs, above and below the cluster of female florets (fig. D, Pl. III).

In *R. maritima* the female florets appear as small, long pearshaped bodies (ovaries) varying in number from 2 to 8(9) in different stages of development between the anthers—

the central anthers are adjacent. (Fig. N).

Pistil: The pistil is long pyriform varying somewhat in shape in response to the compression surrounding it. It also varies in age from its neighbours thereby accounting for the apparent differential growth between the pistils in each cluster. The stigmatic area is somewhat bun-like in *R. maritima* and canopy-like in *R. rostellata*.



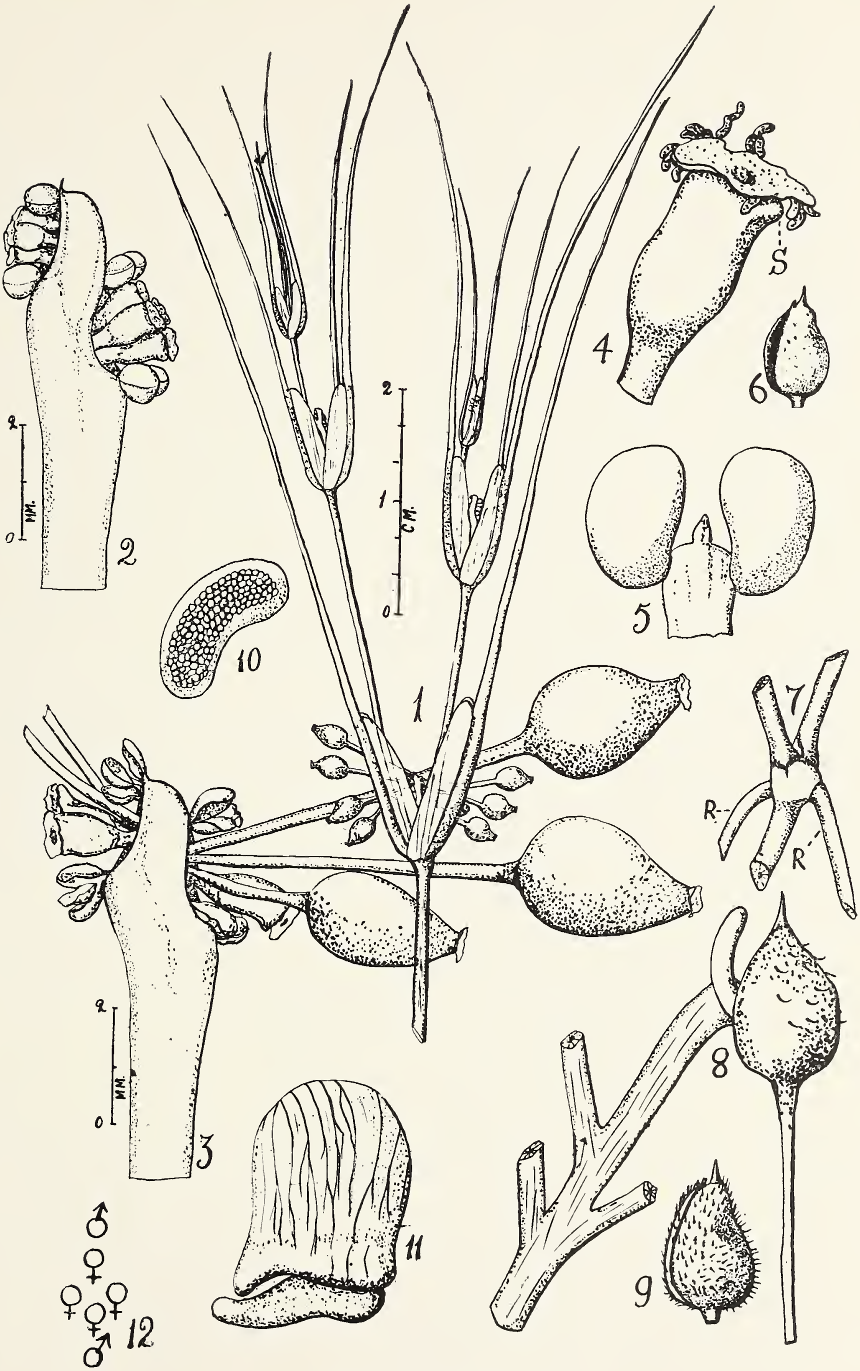
R. maritima Linn.
Cross section (diagramatic) through peduncle showing groups of stipes and mode of rotation to form spiral.

Anthers: In *R. maritima* the anthers are solitary and sessile arranged in a tier along the peduncle whereas in *R. rostellata* the anthers are arranged in pairs on a short filament above and below the female clusters (Pl. II, 5). The anthers dehisce under water freeing the sausage-shaped pollen. The pollen contacts the stigmas on its way up to the surface and also at the surface in *R. maritima* as the clusters of florets on either side of the peduncle keep rotating at the surface of the water by the movement of the wind and wave action. Unlike *maritima*, in *rostellata* the pollen contacts the stigmas under water for the greater time but surface fertilization may also take place.

Soon after fertilization the stipes begin to elongate, they may be equal or unequal in length depending on the degree of maturation, however, they finally become subequal in length.

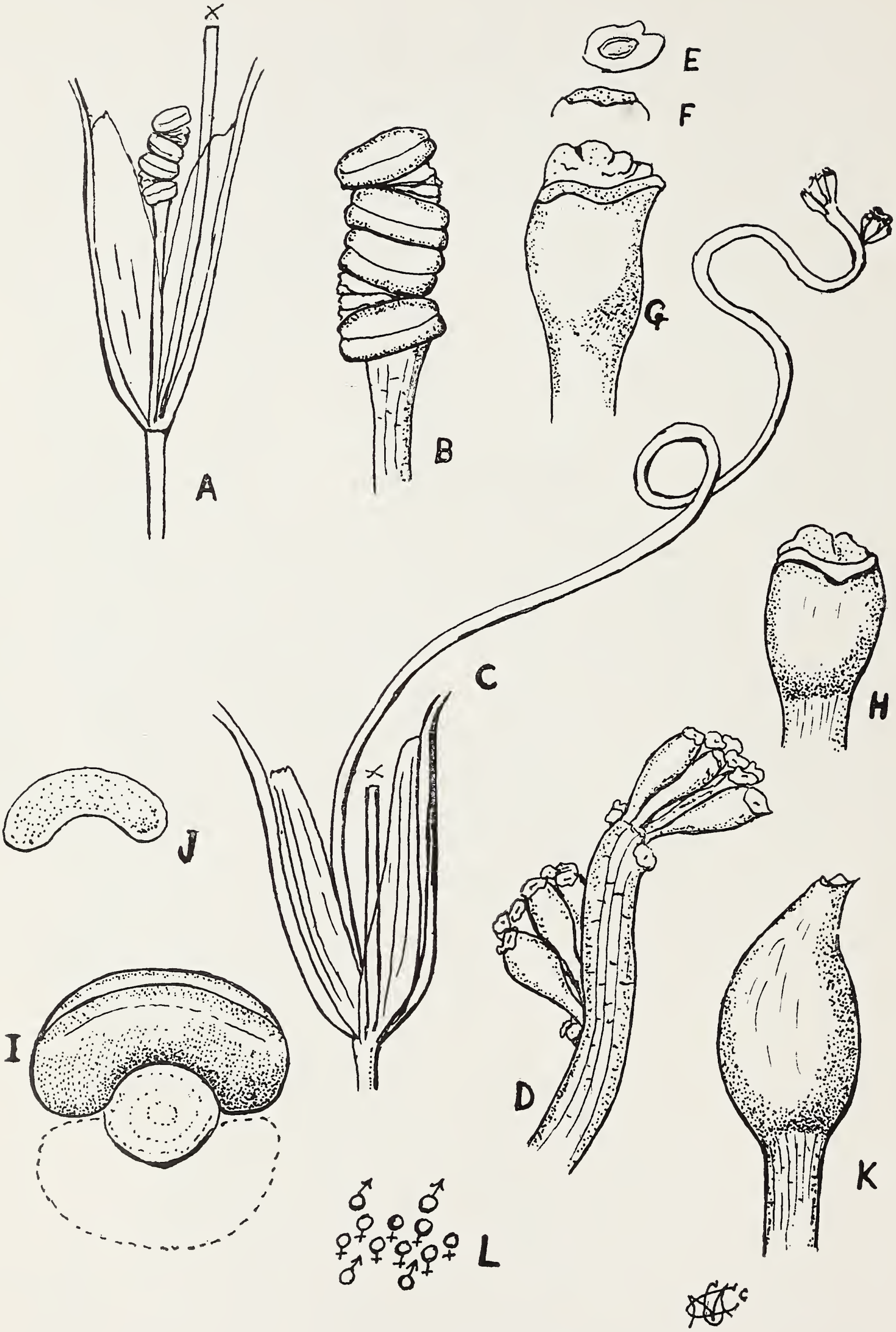
Pollination:

The pollination of the florets of the two species of *Ruppia* presents some interesting details. In the Indian species (*rostellata*) the anthers release their pollen under water and as it rises towards the surface of the water the reniform granules are arrested by the stigmatic canopy and remain adherent to it, moving



Ruppia rostellata Koch

Fig. 1. Portion of plant; Figs. 2 & 3. Peduncle and florets; Fig. 4. Pistil; Fig. 5. Stamen; Fig. 6. Dehesed achene (shell); Fig. 7. Node with roots; Fig. 8. Rhizome with shell of achene attached; Fig. 9. Achene after decomposition of pericarp; Fig. 10. Pollen grain; Fig. 11. Embryo; Fig. 12. Disposition of male and female florets.
[Del McCann (1945)]



Ruppia maritima Linn.

Fig. A. A portion of stem (winter); Fig. B. Inflorescence (winter); Fig. C. Developing peduncle and inflorescence (summer); Fig. D. Female florets minus males; Figs E. F. & G. Aspects of stigma; Fig. H. Pistil; Fig. I. Anther; Fig. J. Pollen grain; Fig. K. Fruit; Fig. L. Disposition of male and female florets.

[Del McCann]

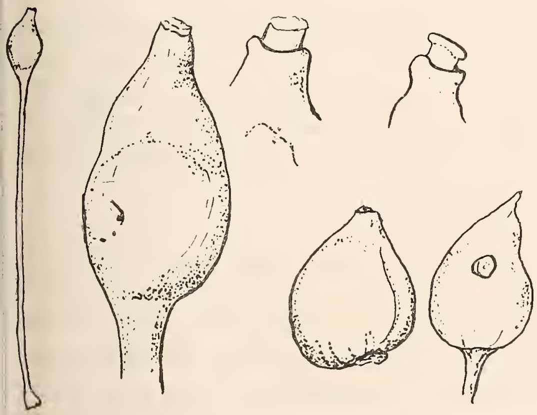
round to the stigma with the occillation of the water.

In the New Zealand species (*maritima*) the mode of pollination is somewhat different. The pollen is dispersed before the maturation of the stigmas and rises to the surface of the water, there to float about at the whim of the wind and the currents like a sea of pollen dust. The elongating peduncles carry the two clusters of female florets to the surface. As the peduncles elongate the clusters keep on rotating forming the spiral and keep the stigmas in both clusters changing their position giving all the stigmas a chance of pollination.

The coiling of the peduncle not only serves to adjust the florets to the varying depth of water with the rise and fall of the tides, but its action assists in the rotation of the opposed female clusters to ensure complete pollination of the florets.

The difference in the mode of pollination between *maritima* and *rostellata* is very significant.

A point worthy of note is that, in *maritima* the peduncle does not re-coil after pollination as do the *pedicels* of *Vallisneria*, but with the aging of the tissue the spiral tends to close in *Ruppia.*



Stages in the development of the fruit *R. maritima.*

Fruit:

After pollination the stipes begin to lengthen either uniformly or unevenly according to the interval of pollination between one floret and the other, but eventually all stipes attain approximately the same length. During the process of development the two clusters keep on rotating increasing the coils in the spiral (*R. maritima*). In *R. rostellata* the stipes just elongate till the fruit are ready to fall. At first the fallen fruits float for a short while before sinking into the ooze or being caught up in other vegetation, particularly, drifting algae.

The shape of the achene varies slightly from ovoid, obliquely-ovoid to subreniform, somewhat compressed. The seed is protected by a submembraneous testa. On dessication the stipe coils slightly in various ways and thus forms a short prehensile tail to the achene for a time, suitable to attach in the down of water fowl.

Habitat:

Ruppia is essentially an aquatic plant adapted to live in brackish or saline water, salt marshes, lakes and lagoons, but it cannot withstand too rapid currents nor too high a degree of salinity. Although brine soon destroys the vegetative tissue, the seeds are capable of surviving it.

Vegetative growth commences with the influx of freshwater, winter rains in the case of *R. maritima* or the monsoon rains in the case of *R. rostellata*, which inundate the habitat. The induction of the freshwater encourages growth, and eventual flowering and fruiting until the increased salinity above the tolerance level or a drop in temperature brings about the cessation of vegetative growth till the next season.

The Indian species, *R. rostellata,* commonest in tidal marshes around salt works commences life with the break of the monsoon rains when the habitat is diluted with freshwater (approx. middle June annually). The residue of salt left in the soil of the works from the previous salt-working season provided the necessary amount of salinity for favourable growth. The plants flourish throughout the monsoon producing a prodigious amount of vegetative growth followed by masses of flower and seed. During this period the saltworks are subjected to the rise and fall of the tides, by way of the channels, and inundate the area. It is with the advent of the monsoon that numbers of fish, particularly mullet, locally known as *boie,* enter the area to breed and feed on *Ruppia* and its seed. By the end of the monsoon (September-October) the migrant birds are on their way and the waders and anserines find these *Ruppia* beds a haven. It is about this time that the Benas River floods the great Rann of Cutch and the hordes of Flamingos find a suitable breeding ground, (McCann 1935).

During the early development of *Ruppia* vegetable feeders, accompanied by the chain of predator come inshore to feed or breed or both: among the hordes are crustaceans, fish, sea-snakes, and some of the migrant birds of prey which reap a harvest.

As the year advances and the salinity increases by evaporation the plants die off leaving much seed embedded in the mud. This is but a very brief reference to the transition that takes place during the life cycle of *Ruppia rostellata.*

In the New Zealand species *R. maritima* a very similar pattern to that of *R. rostellata* emerges, but with a change of the season and the temperature. With the approach of the winter and winter rains, *R. maritima* begins to die off, leaving old stolons and seeds to fill the gap in the spring. In the close mats of vegetation growing in the loam bordering the rise and fall of the tides in shallow water, *R. maritima* mingles with species of small cyperaceous plants, *Scirpus,? Selliera radicans* Cuv-(Goodeniaceae); *Crantzia lineata* Nutt. (Umbelliferae) and a few other small salt tolerent plants. In such situations the stolons of *Ruppia* become tightly matted in competition with the roots and stolons of its associates. Under such circumstances the plants themselves are short, with short tightly coiled spiral peduncles with or without florets or achenes. Much green algae is also found tangled in the sward.

In the tidal lagoons small and large floating 'carpets' of green algae often harbour much *Ruppia* beneath them. In the summer these carpets of algae may be found stranded with the *Ruppia* under them. The fall in the level of the water leaves the anchored *Ruppia* and its 'umbrella' of algae high and dry, completely dessicated. During the winter much of the algae (now brown and decomposing) tangled with *Ruppia,* may be found drifting and stranded ashore after stormy weather.

With the advent of spring migratory birds commence arriving in New Zealand and those which are resident in the country, change their residence according to the climatic changes to more favourable feeding and breeding grounds.

Seed dispersal:

There is little doubt that aquatic birds are largely responsible for the dispersal of *Ruppia* throughout the world. The carriage of the seeds or viable fragments of the plants may be external, by attachment to the plumage by the 'hooked' stipes or in clots of mud attached to other parts of the body: or, internally, in the alimentary canal, by way of the food (without the stipes) some of which may escape the gastric juices and are voided a long way from the original places of collection. Sick birds dying by the way and those falling victims to birds of prey which invariably scatter the contents of the crop, stomach or gut of the victims. The chain is almost endless. Thus the birds of prey, which are often on the routes of migration followed by the aquatic birds may also perform the role of dispersal agents.

Distribution:

Ruppia is widely distributed throughout the world, in salt or brackish water, in maritime coastal regions. It is also able to survive in freshwater (non saline) for a time. The extent of saline tolerance undoubtedly varies with the species, and according to the time of the year.

Ridley (1930) on seed dispersal writes: "*Ruppia maritima* is another world-wide aquatic found on the coasts of Europe, Asia (India, China, Formosa), Malay Peninsula, Philippines, south Africa, Socotra, Canaries, Madeira, Australia, New Caledonia, New Zealand, all America and West Indies, including Bermudas, probably mainly dispersed by ducks." (p. 694).

Ridley refers to a single species, *R. maritima,* but the extent of the distribution referred to by him covers both the species *maritima* and *rostellata.* The present status of the various species believed to exist (beyond the two mentioned above) is open to question and needs careful scrutiny. So far I have been unable to discern more than the two species mentioned above from a comparison of the numerous descriptions examined. In some instances, I do believe, that the fine-foliaged species of *Potamogeton* have been confused with species of *Ruppia* and *vis-à-vis,* for the species of both genera (*Potamogeton* and *Ruppia*) frequently co-exist in the same habitat together!

Perhaps, *Ruppia filifolia* (Phillippi) of the Andies, S. America is an example. This *Ruppia* was originally referred to as *Potamogeton filifolia* by Prof. Phillippi but was not actually described by him; however, Skottsberg (1916) transferred Phillippi's *P. filifolia* to the genus *Ruppia* as a new combination. My interest in *R. filifolia* arose from a reference to it in the *Chester Zoo News* (September, 1974:7 to 9) in connection with the aquisition of rare Andean Giant Coots. In this reference Mr. A. W. Johnson of Santiago, Chile, who obtained the birds for the zoo on a small lake at 14,000 feet above sea level and subsequently, with the aid of an Indian guide, at Lake Cotacotani, a snow fed lake very much higher. According to Mr. Johnson, the birds bred in these areas making large floating nests or nest rafts "built from the fibers of the same aquatic plant *Ruppia filifolia,* which also forms part of the coots' diet and each platform was anchored beneath the surface." (p. 12) Giant Coot—*Fulica gigantea.*

Of the two species discussed here *R. maritima* is the more widely distributed than *R. rostellata;* the former appears to be the tougher of the two occurring in the more maritime and colder conditions than the latter.

In New Zealand the all pervading maritime species, *Ruppia maritima* is associated with *Potamogeton pectinatus,* a very similar looking plant, in some respects, and plays an important role in the farming of game birds, such as ducks and geese as well as the major feed for migrant waders whether from overseas or birds subject to 'local' migration in response to the climate conditions. The movements of the Godwits (*Limosa lapponica*) are a good example of the exotic migrants and the Oystercatchers (*Haematopus* spp.) and the Wrybill (*Anarhynchus frontalis*) are suitable examples of internal migrants. To carry these observations further, *Ruppia* probably contributes to the coastal fisheries—the chain is almost infinite.

Ruppia is closely associated with the mollusc, *Melanops trifaciate* Gray which feeds and breeds in large numbers in the tangled masses of the plants. Likewise many small and minute crustacea (copepods) find a haven in the shelter of *Ruppia*. A small coleopter (or dipterous) larva lives in the achenes possibly feeding on the contents, while the fruit is still on the plant; this may account for the hole so frequently seen in the dried seeds and in illustrations. There is much to be gleaned from a closer study of the microcosm.

In India, *Ruppia rostellata* frequents the tidal marshes and the adjacent salt-pans. These pans and marshes are the annual resort of numerous species of migrant waders and anserines as feeding grounds.

The Great Rann of Cutch is perhaps the best example where thousands of Flamingos (*Phoenicopterus ruber*) go during suitable years to breed in the marshes formed by the blind Benas River diluting the salt of the Rann. The Rann is for a brief period covered with *Ruppia rostellata*.

During the early part of the monsoon, the saltworks are inundated and the coastal water becomes diluted and suitable for the growth of *Ruppia*. During this period vast hordes of Mullet (*Mugil* sp.), the wellknown 'boie' of the local fishermen around Bombay, enter the channels around the works with each tide to breed and feed on the escape of debris and *Ruppia* in the area. Along with the mullet come numerous other fishes, crustaceans, cephalopods (cuttle-fish) and sea-snakes. This chain of natural resources is forged annually and will continue if not interfered with by 'modern' fishing devices and the animal life given a short respite to breed and not subjected to capture and pollution throughout the year. By the end of the monsoon the avian migrants are on their way to renew the cycle.

ACKNOWLEDGEMENTS

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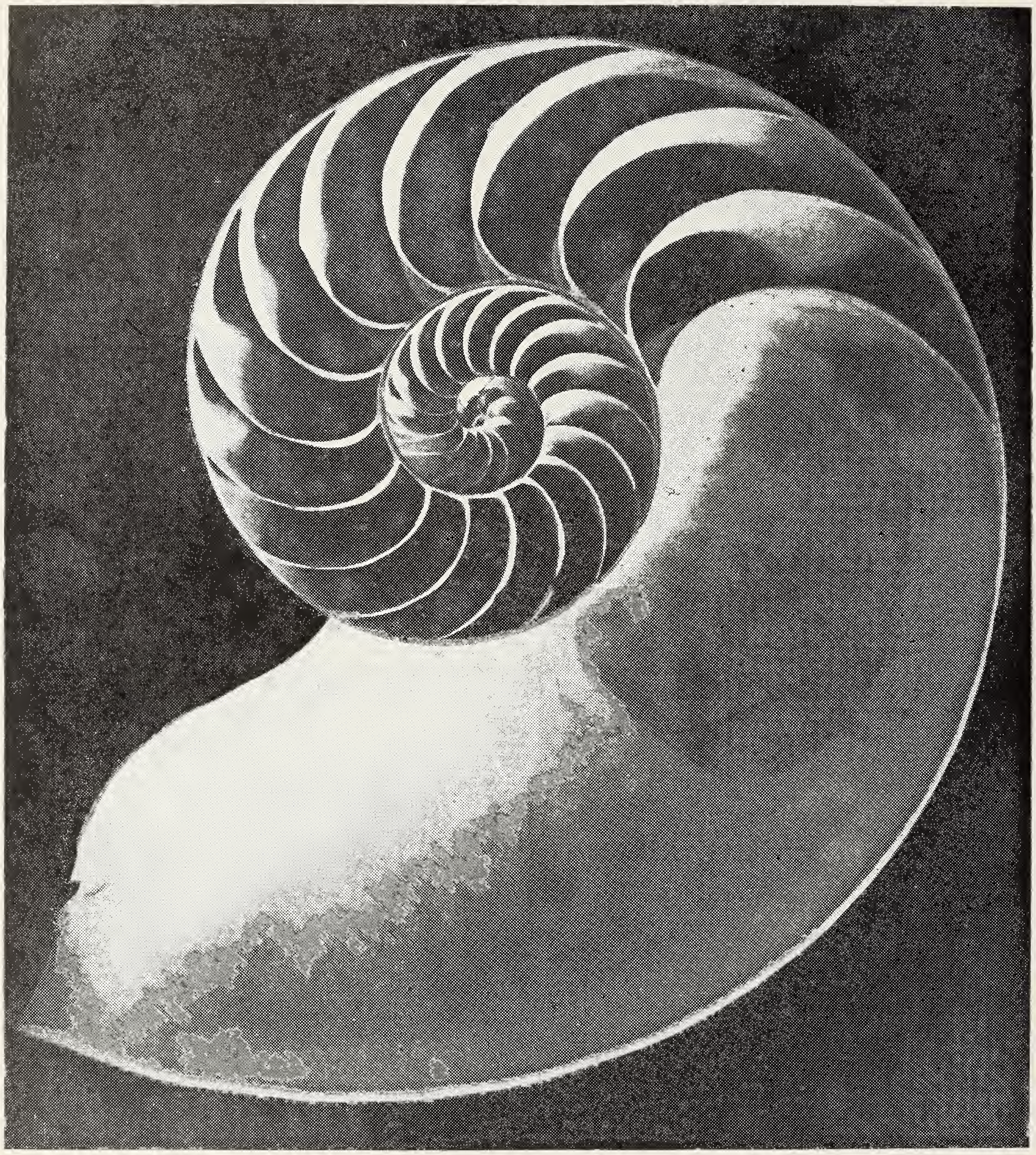

Transverse view of a chambered Nautilus (*Nautilis* sp.) showing the various chambers and the margin of the shell that forms a beautiful logarithmic spiral.
(*Photo*: Author)

THE SHAPE OF THE SHELL OF THE CHAMBERED NAUTILUS

NATHANIEL GROSSMAN[1]

(*With a plate*)

Of all the natural beauties, one of the most acclaimed is the shell of the chambered nautilus (*Nautilis* spp.). Painted, drawn, and photographed innumerable times, saluted in poetry, its graceful shape appeals to all viewers, even the artistically ungifted. Scientists too have fallen under its spell and have speculated at length on reasons why the animal builds its shell in one particular shape, a shape that is found also in shells of other molluscs, living and extinct, in ram's horns, in saber teeth, and in other animal structures, as well as in various botanical settings.

After discussing differences in the development of animals and plants displaying a spiral structure, D'Arcy Thompson asserts: "It follows from all this that there cannot be a physical or dynamical, though there may well be a mathematical *law of growth*, which is common to, and which defines, the spiral form in *Nautilus*, in *Globigerina*, in the ram's horn, and in the inflorescence of the sunflower" (1971). From all the properties of the logarithmic spiral, he selects as the key one its continued similarity with itself as it grows.

This is assuredly a beautiful and unique property of the logarithmic spiral, but it asks a lot of the animal that builds the shell. The creature must constantly be surveying the whole of its past shell-work to keep its current addition in line with the global requirement of self-similarity. We prefer to give a local explanation for the shape and we offer one that is biologically simple and plausible and, moreover, does not require the animal to know any mathematics. The basic hypothesis certainly can be experimentally tested in a number of different situations. Our explanation is biologically dynamic and not merely descriptive and numerological, as phyllotaxis is.

We suppose that, as the shell is enlarged, the shape of the rim (or tube cross-section) remains similar to itself. We suppose that the animal deposits new shell material at the rim at a rate proportional to the circumference of the rim. (There is, furthermore, some mechanism to keep the shell attached to itself as it coils.) Finally there is a condition, to be explained later, for which we can think of no name better than "embryological predisposition".

Using polar coordinates, express the equation of the shell coils as $r = f(\theta)$. Because of the similarity of cross-sections, the circumference of the rim is proportional to a characteristic length, say the "height" of the tube: $f(\theta) - f(\theta - 2\pi)$. Since the rate of deposit of shell material is then proportional to that height, there is a constant k so that

$$f'(\theta) - f'(\theta - 2\pi) = k[f(\theta) - f(\theta - 2\pi)].$$

It is easy to verify that $f(\theta) = f(o) \exp k\theta$ is a solution of this differential-difference equation.

It is crucial to note that, under a suitable condition, the solution just found is unique. To see this, suppose f to be a specified differentiable function when $-2\pi \leq \theta \leq o$. Then the equation can be thrown into the form

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$$f'(\theta)-kf(\theta)=f'(\theta-2\pi)-kf(\theta-2\tau).$$

This can be treated as a linear differential equation with known forcing function on the interval $o \leq \theta \leq 2\pi$ and the solution, which is unique, can be written out explicitly if desired. The process can be repeated on the next interval $2\pi \leq \theta \leq 4\pi$, and so on. Hence, it is enough to specify f for $-2\pi \leq \theta \leq o$ and this the animal does in some still unknown way. This is what we referred to as the "embryological predisposition". (It is, of course, a mystery of science but, we think, a genuine and biologically relevant mystery in contrast to numerological ones such as phyllotaxis.)

The foregoing applies as well to other gastropods. Furthermore, it covers the ammonites, an extinct genus of cephalopods, which do not spiral inward toward a point but instead toward a limit circle.

REFERENCES

D'ARCY THOMPSON, (1971): On Growth and Form (Abridged Edition, J. T. Bonner, ed.), Cambridge University Press, pp. 173-174. This edition has references to recent work on phyllotaxis. For a survey of older work on phyllotaxis, see the earlier editions of Thompson's book.

EMOTIVE KINSHIPS IN THE STUDY OF MAMMALS

M. KRISHNAN[1]

The pursuit of knowledge begins with names. Shakespeare himself, and thousands after him, seem to have missed the true significance of his much-quoted line, "a rose by any other name would smell as sweet"—its point, of course, is that it must have some other name if we do not call it a rose, to be recognized at all, that the human mind needs tags and labels to apprehend and remember things. Naturally, the study of animals was much concerned, in its early stages, with distinguishing them apart from one another, sorting them out, and giving them generic and specific names, with anatomy, morphology and taxonomy.

That is still going on. Among some animals (insects, for instance) diversity is so profuse that lists are still being extended and revised. Further, deeper studies in palaeontology, more precise morphological descriptions, and similar enhancements of knowledge have led to revisions and realignments of taxonomy. However, it is true that concurrently with the cognizance of different animals, there were also assessments of their habits and "character", usually at entirely anthropomorphic levels—something inevitable when we consider that the utility of animals as providers of food, pelts and assistance to humanity (anthropologists have said that without the domestication of the dog and cattle, human civilization could never have progressed beyond a more or less feral stage) was something constantly investigated even prior to the systematic study of other animals by men. While the overwhelming majority of such early studies was certainly unscientific by modern standards, it is necessary to note that bits and pieces of quite accurate and reliable observation were not lacking in this vast, conglomerate mass of highly anthropomorphic and imaginative natural history and legendary lore. Three examples may be cited to make this point. Fear and avoidance of men, an almost universal reaction of wild mammals, was strangely lacking among dolphins and replaced by an almost friendly tolerance, as noticed very early by the Greeks. The oldest extant Tamil poetry (which bears ample evidence of an earlier body of literature now irretrievably lost to us) is about 18 centuries old. In it are two poems which refer to bird migration as something well known. One of these describes the White Stork unmistakably and vividly, and its turning home northwards after its winter sojourn in the south: the other poem refers similarly to the flamingo flying northward after sojourning in the lagoons near Kanya Kumari, and mentions in a terse but quite specific line its habit of feeding on micro-organisms in the silt of the shallows—how many centuries later did Western science comprehend the marvel of bird migration, and realise that the flamingo's beak is specially adapted for feeding on minute prey!

Such rare, fragmentary nuggets of truth in early natural history should not blind us to its overwhelmingly romantic and imaginative (and at the same time quite callously utilitarian!) bias. There were good animals and bad animals, the noble lion and the shifty and cunning jackal, in that lore, and the ferocity of most wild animals was much exaggerated. Only in the early decades of this century (and somewhat earlier) did natural history develop more factually informed, investigative and objective trends, but these were rapidly developed and along many lines of inquiry.

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Meanwhile, right from the middle of the 19th century to almost the middle of the 20th, human interest in wildlife was dominated by the desire to encompass its end. Shikaris of various descriptions were the main sources of information about wild animals, and while some of them were knowledgeable naturalists and keen observers, the fact remains that when their chief interest in their quarry lay in bagging it, they learnt only enough about it to do so expeditiously and effectively. In the preface to his WILD ANIMALS IN CENTRAL INDIA, a book that achieved renown as much as a natural history as a text on shikar, Dunbar Brander himself says this.

The great renaissance in natural history was in the first half of this century, when much carefully verified knowledge on diverse animals and their lives was gained and integrated: though these various investigations were often channelled along particular lines, since all of them were scientific studies of animals they complement and supplement one another to form a whole, and are not merely isolated and disconnected fragments.

During the present century, taxonomical and habitat evaluations have been carefully revised; instinctive urges and inhibitions, responses and reflexes, have been recognized as of vital importance in animal life, and closely studied; spectacular advances have been made in the field of animal senses and sensibilities by means of meticulously planned investigations, and their vast variations from our own sense-perceptions and from those of one another have been appreciated; the study of animal behaviour has been extended to free-living subjects in a wholly natural environment, with the realisation that captive specimens may not provide reliable material except in limited ways, and that their behaviour might even be misleading; the complex and vital relationship between wildlife and environment and the importance of revising our ecological knowledge have been better appreciated; with advancement in other fields of scientific knowledge and technological improvements, biological studies have also gained precision and reliability by utilising these advances. This is no summary of how and in what fields natural history has gained considerably during the past 50 years or so, but only a list of illustrative examples. More theoretical researches, not always marked by consensus of opinion, have also been undertaken or achieved in this period, as in the fields of genetics and evolution.

On the whole the trend has been towards the employment of scientifically planned inquiry that will, to the extent possible, minimise human errors in assessments, and the use of mechanical instruments of record, and statistics of all kinds. Undoubtedly such means are of considerable value and validity, but since the exploiters of all such means are human and therefore fallible, perhaps less has been achieved than is generally conceded. The quality of the in-put, and the dependability of skill in utilising instruments of record, will naturally materially affect the conclusions reached by mathematical and mechanical means, but we need not go into this question here.

All that I wish to point out here is that this increasing reliance on mechanical means, statistics, and modern 'methodologies' (i.e., methods!) seems to reflect a revolt from the anthropomorphic and romantic natural history of the past. By no means does modern science reject or deny means of information or comprehension that are not purely intellectual, and the work of great naturalists of our own times, like Tinbergen and Lorenz, proves again and again that to treat live, sentient subjects as a mass of conditioned reflexes and instinctive responses is utterly futile, and that we cannot really understand animals by mechanical means and statistical columns.

Anyone who has known a dog well (and not merely owned it) will know that although its colour blind world of smells is something we cannot even begin to understand except on an arid, intellectual plane, we can certainly be sure that it shares many emotions with us. A dog may be frightened, angry or happy (in high spirits), in emotional states distinct from purely physical or physiological states also known to us personally, such as being fatigued, sleepy or hungry. Those who have had closer associations with animals will also have sensed the need for reassurance (as by means of physical contact or proximity even) that develops at times in such relationships, even on occasion the provision of such reassurance or support by the animal to the man.

Our sense-perceptions are very different from those of most animals, both in range and reach — some animals even go by perceptions quite unknown to us. When this is so, it may seem difficult, and impossible at times, for us to apprehend their expressions of moods and emotive urges, especially as it is reasonable to assume that their intraspecific communications would be along the senses best developed in them. No doubt this impediment to our comprehension of animal communications is there, and is less easily got over than the majority of naturalists seem to realise, but it is a real handicap only in human understanding of social and personal animal communications, when these are interpreted in terms of our own perceptive capacities. An example will clarify this difficult sentence: it is well known that animals of the dog tribe can hear sounds pitched high above our auditory reach: the evening chorus of jackals (little heard these days with the decline of the animal in most places), often described in detail in highly humanised terms, possibly features overtones we are unable to hear but which may hold specific meaning to other jackals which can sense subtle variations in the call, but so long as we do not make the mistake of presuming that jackals hear the call of their kind precisely as we do, we are on sound ground in assuming the purpose of the chorus is mainly a social location announcement, and at times perhaps an assembly summons.

It is specially with regard to olfactory perceptions that we are handicapped, because on this frontier our own sensibilities are singularly blunted, while in most animals they are exquisitely perceptive and also capable of selective apprehension. However, smells and scenting abilities are of importance to animals mainly in locating others of their kind, in hunting, as territorial markings, and in personal relationships (as in seeking and finding mates or in the mother-young association), and are seldom featured in emotive expressions. As the manifestations of emotional states are mainly visual, tactile or audible, it is possible for us to have a fairly reliable understanding of such tokens, provided our observation is adequately informed by experience.

Attitudes, bodily movements and gestures, and visually manifest excitement or lethargy are highly expressive of an animal's mood. Dogs wag their tails in friendly overtures and tuck their tails between their hind legs when frightened, cats arch their backs, raise their tails vertically and bristle their hair in counter-threat, and cattle and horses indulge in nuzzling and nudgings in expression of confiding affection—licking, which is mainly a tactile expression of reassurance, is also freely indulged in by many animals and is something that can be seen. These are emotive expressions well known to us because we have known domestic animals long and intimately, but similar postures, movements and activities by wild animals, typical of emotional states or moods, are no less symptomatic.

Wild elephants, for example, are contented and in an equable frame of mind when flapping their ears casually, flicking their tails, and moving around or feeding in a leisurely manner; when the ear movements are accelerated, the tail curled tight over the rump, and they pace about more actively, they are in a boisterous mood, in high spirits; when standing immobile without any swaying movements of the body, with the ears held flat against the sides of the neck they are in a rage, and it is time to take oneself far away swiftly and unostentatiously! A peculiar token of elephantine uncertainty or puzzlement, distinct from fear or anger, is that when aware (mainly by sight) of the proximity of something distrusted, as a man in the offing, the trunk is looped over the tusks (in bulls) or its tip taken to the lips or ears, often in a scraping or scratching movement,—they may also indulge in the movements of feeding then, without actually feeding—this indulgence in familiar actions in a purely formal manner is a form of displacement activity characteristic of most mammals when uncertain or uneasy but not yet frightened or provoked, and serves to reassure them.

A mistake the observer is prone to when insufficiently experienced is to take these manifestations of mental states or moods as unvaried and invariable expressions—that is very far from being so. For instance, as a man who has been chased and charged by wild elephants and who has provoked a charge to demonstrate it to others, I may say that the preliminary pawing of the earth with the forelegs and the orientation of the body to face the cause of provocation, often characteristic of a charging elephant, may not be indulged in at all—the charge may be launched with no preliminary indications (especially when an elephant has sensed human presence by smell) and may not be in a straight line but in an in-curved arc—it may be made in silence (as it is usually) or may be accompanied by bloodcurdling screams—the tight curling up of the trunk prior to charging, so often described as typical of elephants, may not be indulged in at all and the trunk may hang loose and sway with the impetus of the charge. A more significant point is this. It has long been known that elephants (both cows and bulls) often put on a threat display or demonstration to scare away human intruders. At times (probably because of the response of the intruder to the demonstration) this mock charge, instead of being averted at the last minute, may be pressed fully home and result in a killing —it is hardly possible to determine what sparks off an aggressive display motivated by fear or uncertainty to a panic reaction of hostility.

Such visually perceptible indications of moods and emotive states are, obviously, involuntary and not intraspecific only in their communication but also inter- or extra-specific. Vocalisations or other audible sounds indicative of an animal's feelings are mainly of the nature of intraspecific communications, but may also be involuntary and extraspecifically comprehended—for example, snarling and roaring by some animals and the alarm calls of others.

Few aspects of animal life are more fascinating to study or more rewarding than this attempt to understand their emotive expressions, but at all times the human observer must not fail to keep two things in mind: first, even visually communicated tokens may be differently apprehended by the animals than by us and, second, these expressions, being conditioned by many variables, are not to be interpreted too narrowly or definitely.

MOTH MIGRATION IN MOMBASA—1955/1977

D. G. Sevastopulo[1]

The use of Mercury Vapour light in East Africa has, as elsewhere, increased our knowledge of the Heterocera considerably; numbers of new species have been discovered, species previously considered to have been extremely rare have proved to be common (the strange Syntomid *Paramelisa lophura* Auriv. in Kampala, for example), and, furthermore, it has shown that the migration of moths is probably more frequent, and covers even more species, than the more spectacular and more widely publicised migration of butterflies. I have only once witnessed an actual migration of moths, a flight of the noctuid *Achaea catocaloides* Guen. in Kampala in March 1954, which was crossing the lawn in my garden in countless numbers at dawn, during the day the moths rested on and in a well-clipped Macrocarpus hedge, giving it the appearance of an English Beech hedge in winter.

It is often possible to make an intelligent guess about a migration by noting a sudden increase in the numbers of day and dusk feeding Sphingids visiting flowers, or by the increased numbers of certain species being disturbed from grass or rough herbage, but migrations by many species cannot be detected in this way and can only be revealed by the regular use of a mercury vapour lamp.

I consider that a migration can be assumed as having taken place when a species, previously absent or present in very small numbers, suddenly appears in large numbers at m.v. light and then, equally suddenly, disappears. The assumption is strengthened when captive females, with known larval food-plants (our knowledge of the food-plants of East African Heterocera, except those recorded as attacking agricultural or horticultural crops, is still woefully meagre) refuse to lay, and which are subsequently found by dissection to have the ovaries undeveloped and the abdomen full of fat. I can, in fact, only recall four occasions when I have found larvae of known migrant species in numbers large enough to pre-suppose them to be the progeny of migrants—larvae of *Spodoptera exempta* Wlk., the notorious Army Worm of East Africa, on Mombasa Island in December 1955/January 1956, larvae of *Plecoptera hypoxantha* Hamps. and *Achaea lienardi* Bsd. in a coastal forest south of Mombasa in April 1971, and of *Cambogia grataria* Wlk. in the Shimba Hills in July 1973.

I can think of only two references to moth migration in Africa, the very specialised work of the late Eric Brown and his team on forecasting outbreaks of Army Worm (*Spodoptera exempta* Wlk.) in East Africa and a paper by D. F. Owen (1969, Species diversity and seasonal abundance in tropical Sphingidae, *Proc. R. ent. Soc. Lond.* (A) 44:162-8).

Most migrations on the Kenya coast take place during the rainy season, the 'long rains' normally from late March to late May or early June, and the 'short rains' in October/November. The prevailing winds during the long rains are from the south east and from the north east during the short. Of recent years, however, the long rains have tended to start late or finish early, and the short rains to fail more or less completely.

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During the last ten or twelve years migrations appear to have become more frequent, or what is more likely to be the case, have become more obvious. There has been a considerable decline in the numbers of resident moths, both species and individuals, during this period, probably due partly to the reduction of uncultivated bush through building, and partly to the dry cycle through which the coast has been passing. Whatever the cause, species that used to come regularly month-in, month-out, to my m.v. lamp now appear infrequently or not at all, so that small migrant influxes, which previously merged more or less unnoticed in the resident population, now stand out conspicuously.

A study of the details below will show that, in many species, migration is not a once and-for-all affair each season but occurs in a series of waves, which may overlap or be separated from each other by intervals of a few days. Furthermore there is very strong evidence from the variation in the proportion of the various forms in di- and polymorphic species that these waves originate from different areas.

From 1956 to late 1959 the lamp was situated on Mombasa Island itself but, to avoid annoying neighbours, was usually switched off at about 10 p.m. From April 1960 onwards the lamp has been situated in Nyali, a residential area on the mainland, immediately north of Mombasa Island, and has been left on from dusk to dawn, except for brief periods of furlough or illness, these, except for a period from 5.v. to 25.v.71, have been during periods of minimal migratory activity.

I propose dealing with the question, family by family, in the order adopted by Seitz in the MACROLEPIDOPTERA OF THE WORLD.

CASTNIIDAE, ZYGAENIDAE, HETEROGYNIDAE and SYNTOMIDAE—I have no evidence of migration by any Zygaenid or Syntomid, the only families of these four that occur at the Coast.

ARCTIIDAE—The only two species that appear to be regular migrants are the Hypsids *Digama aganais* Feld. and *D. africana* Swinh., both species usually taking part in the same migration. Migrations have been recorded in:-

11/13.xii.58 (many *aganais*, few *africana*).
21/29.xii.62 (both species in equal number).
2/4.i.65 (*africana* only).
1.iii.68 (two *africana* only).
21/22.iii.72 (both species).
24/27.xi.72 (both species).
11.xii.73 (three *aganais* only).
1.iv.74 (both species, few only).
8/10.iv.75 (both species, few only).
21.iii.77 (one *africana* only).
27.iii.77 (two *aganais* only).

Two species pose a bit of a problem, a female *Godasa sidae* F., *orientis* Brtl. appeared at the light on 4.viii.76 and another on 20.iv.77, and a female *Caryatis hersilia* Druce on 6.vi.75, these are the only records for these two species over the whole period under review. Presumably they should be classed as occasional vagrants.

PTEROTHYSANIDAE—Does not occur at the Coast.

LYMANTRIIDAE — Only two species have shown any signs of migration. On the morning 23.viii.68 vast numbers of *Cropera testacea* Wlk. were seen settled on the walls and ceiling of the airport lounge at Port Reitz, the Mombasa Airport. On my return from Nairobi that same evening, even greater numbers were flying round the airport lights. This grass-feeding species is decidedly scarce on Mombasa Island and does not occur at all in Nyali.

The second species, *Sapelia tavetensis* Holl., appears every now and then in fair numbers for a few days, and then disappears. Dates of such occurrences are as below:—

18.vii.66
18/20.x.72
10/11.vi.73

The great majority of visitors are males. I have only once found larvae of this species, in April 1975 a small number were found on an unidentified tree belonging to the Bombacaceae, almost certainly non-indigenous.

LASIOCAMPIDAE — Lasiocampids, with their inability to feed and the unwieldy, egg-filled bodies of the females, appear unlikely migrants. One species, *Trichopisthia monteiroi* Druce, has on several occasions in recent years appeared suddenly in considerable numbers and then equally suddenly, disappeared. The females lay without hesitation, and it appears to be far more likely that these mass appearances are the result of simultaneous emergences, the larvae feeding gregariously on *Sclerocarya caffra* Sond. (Anacardiaceae). For the record, mass appearances have occurred on the following dates:—

30.iv/2.v.73
15/16.iv.74
16/17.iv.75

BOMBYCIDAE and DREPANIDAE — No evidence of any migration in these two families.

EUPTEROTIDAE — The general remarks made under Lasiocampidae apply to this family also. There has been no evidence of any migration, but there is one mysterious singleton appearance. A male *Sabalia picarina* Wlk. appeared at m.v. light in October 1972, presumably a rare vagrant.

SATURNIIDAE — No evidence of migration, but on 22.iv.75 and 25.iv.76 single male, and on 4.v.77 a single female *Usta angulata* Roths. appeared at my m.v. light. Also on 12.iv.77, a single male *Epiphora mythimnia* Westw. appeared. All, presumably, to be classed as occasional vagrants from upcountry.

BRAHMAEIDAE — Does not occur at the Coast.

SPHINGIDAE — This family includes a large number of the migratory species. Although food-plants of all the species listed below grow either in my garden or in the adjacent bush larvae, except for an occasional singleton, are rarely found, nor have I ever observed any signs of extensive damage from larval feeding. There is, however, one exception—larvae of *Daphnis nerii* L. occur not infrequently in late May and early June, presumably the progeny of the first immigrants, pupae do not diapause and imagines emerge in July, but there is no subsequent generation of larvae.

Agrius convolvuli L. — 29.xi/8.xii.65 : 21.i.66: 9/20.x.66 : 9.xii.66 : 17/19.iv.67 : 25.x.67 : 11/24.xi.67. There was no noteworthy migration in 1968, a particularly wet year. 13.iv/6.v.69 : 8/10.x.69 : 17/26.iii.70 : 23/24.i.71 : 23/24.iii.71 : 31.iii/3.iv.71 : 6/9.iv.71 : 28.iv/4.v.71 : 14/19.iv. 72 : 8/16.v.72 : 24/25.xi.72 : 3/4.iv.73 : 14/18.iv.73 : 24/29.iv.73 : 11/14.v.73 : 4/7.xi.73: 4/7.xii.73 : 6/17.iv.74 : 20/26.iv.74 : 29.iv/3.v.74 : 17/20.v.74 : 29/31.v.74 : 10/17.xi.74 : 6/18.iv.75 : 25/28.iv.75 : 1/22.v.75 : 3/14.vi.75: 29.x/24.xi.75 : 6/9.xii.75 : 15/17.xii.75 : 23.iii.76: 26/28.iii.76 : 31.iii.76 : 3.iv.76 : 9.iv.76 : 12/16.iv.76 : 18/31.iv.76 : 3.v.76 : 8.v.76 : 14.v.76: 30.v/17.vi.76 : 19.vi.76 : 30.vi/3.vii.76 : 21/22.vii.76 : 30.x/29.xi.76 : 23/25.iii.77 : 27.iii.77: 29.iii/6.iv.77 : 8/11.iv.77 : 14/18.iv.77 : 21.iv.77: 23/25.iv.77 : 27/29.iv.77 : 5.v.77 : 12/13.v.77: 17/18.v.77 : 21.v.77 : 1.vi.77 : 6/8.vi.77. Locally bred specimens occur occasionally all through the year, and can be distinguished by being smaller and with the dark and pale markings on the forewing of the male being considerably less contrasty.

Callosphingia circe Fawc. — 25.iii.68 : 4.iv.68: 2.iv.74. All singletons. My friend, Dr. R. H. Carcasson, classes them as 'vagrants' and states that there are no previous records from the Kenya coast.

Poliana witgensi Strd. — 23/26.iv.73 : 29.iv.73: 17.iv.75 : 19.iv.75 : 30.iv.75 : 2.v.75 : 22.v.75: 29.v/8.vi.75 : 11.vi.75 : 22/27.iv.76 : 30.iv.76: 1.v.76 : 4.v.76 : 1.vi.76 : 30.vi.76 : 2/4.vii.76: 16/23.iv.77 : 26.iv.77 : 29.iv.77 : 1.v.77:4.vi.77:

10.vi.77 : 13.vi.77. No migrations were noted prior to 1973, but they may have gone unnoticed amongst, the then, not uncommon resident population.

Pemba favillacea Wlk — 29.v/3.vi.75 : 8.vi.75: 11/12.vi.75 : 8.xi.75 : 22/24.iv.76 : 30.vi.76: 31.vii.76. Migrants were first noted in 1975, prior to which there had been a small resident population.

Nadiasa contraria Wlk. — 10/11.viii.66. Not normally a migrant, but appeared in large numbers on these two nights.

Likoma crenata R. & J. — 20/21.v.75 : 25.v.75: 30.v.75. The only year in which this species has occurred.

Lophostethus demolini Angas — 15.iv.70. A singleton, another vagrant.

Cephonodes hylas L. — 5.iv.67 : 3.iii.68:5.iv.75: 25.iii.76 : 15/16.iv.76 : 23/24.ii.77. Frequently accompanied by *Leucostrophus hirundo* Gerst.

Daphnis nerii L. — 25/28.iii.69 : 8/15.iv.69 : 18/22.iv.69 : 24/29.iv.69 : 29.iv/4.v.70 : 29.v|14.vi.70 : 29.iv/4.v.71 : 21.iii.72 : 24/26.iii.72: 2.iv.72 : 18/19.iv.72 : 6/9.vii.72:4.iv.73:28.iv.73: 13.v.73 : 24/30.v.73 : 24.vi.73 : 14.xi.73 : 8/15.iv.74 : 22.iv.74 : 2.v.74 : 6.iv.75 : 28.iv/26.v.75 : 30.v/16.vi.75 : 3.xi.75 : 28.xi.75 : 6.xii.75 : 11.xii.75 : 24.iii.76 : 5.iv.76 : 11.iv.76: 17/30.iv.76 : 7.v.76 : 11.v.76 : 17/18.v.76 :22.v/8.vi.76 : 13/17.vi.76 : 21.vi.76 : 25.vi.76:30.vi.76: 6/8.vii.76 : 16.vii.76 : 21/22.vii.76 : 7.x.76 : 19/23.iii.77 : 25.iii.77 : 27.iii.77 : 7.iv.77 : 9.iv.77: 13/16.iv.77 : 19/27.iv.77 : 4/7.v.77 : 10.v.77 : 13.v.77 : 13.v.77 : 16/18.v.77 : 23/30.v.77 : 5/8.vi.77 : 13.vi.77 : 19.vi.77. The June/July moths are almost certainly the progeny of the earlier migrants, but they do not produce a further generation.

Nephele argentifera Wlk. — 24.xii.66 : 3.iv.67: 25.x.67 : 1.iii.68 : 27.iv.68 : 10.iii.69 : 8/30.iv.69: 3/6.v.69 : 1/18.i.70 : 5/7.iii.70 : 15.iii.70 : 17/19.iii.70 : 21.iii/8.iv.70 : 29.iv/7.v.70 : 29.v.70: 2/6.vi.70 : 23/25.i.71 : 22/24.iii.71:27.iii|2.iv.71: 6/9.iv.71 : 28.iv/4.v.71 : 21.iii.72 : 24/26.iii.72: 3/8.iv.72 : 14/20.iv.72 : 8/16.v.72 : 25.iii|4.iv.73: 6.iv.73 : 16/18.iv.73 : 24/29.iv.73 : 1.v.73 : 24/25.vi.73 : 22.iii/17.iv.74 : 30/31.iii.75:2|15.iv.75: 17/24.iv.75 : 28/29.iv.75 : 2/3.v.75 : 6.v.75 : 8/10.v.75 : 12/21.v.75 : 23/24.v.75 : 29|30.v.75: 1/10.vi.75 : 13/18.vi.75 : 29/30.x.75 : 1|4.xi.75: 11.xi.75 : 12.xii.76 : 22/25.iii.76 : 28.iii.76 : 2.iv.76 : 4/5.iv.76 : 7.iv.76 : 10.iv.76 : 19/28.iv.76 : 30.iv/8.v.76 : 15/16.v.76 : 18/21.v.76: 25.v/5.vi.76 : 8/11.vi.76 : 13/14.vi.76 : 16|20.vi.76 : 22.vi.76 : 24.vi.76 : 26/27.vi.76 : 29/30.vi.76 : 3.vii.76 : 6.vii.76 : 13.vii.76 : 15/16.vii.76 : 19/20.vii.76 : 22.vii.76 : 21.viii.76 : 7.x.76 : 19/29.iii.77 : 4/26.iv.77 : 29.iv.77 : 7/8.v.77 : 11/23.v.77 : 25/26.v.77 : 28.v.77 : 2/4.vi.77 : 8.vi.77 : 13.vi.77. Migrations of *N. argentifera* are usually accompanied by small numbers of *N. funebris* F. and *N. bipartita* Btlr., a few *N. comma* Hpffr. and an occasional singleton *N. aequivalens* Wlk.

Atemnora westermanni Bsd. — 15.vi.59 : 24/26.v.60 : 4.viii.65 : 12.v.66 : 17.iv.67 : 28.ii.68: 11/22.iii.68 : 25/29.iii.68 : 5/11.iv.68 : 13.iv.68: 16/24.xi.69 : 18/20.v.70 : 13.v.73 : 31.iv.74 : 31.iii.75 : 14/19.iv.75 : 22.iv.75 : 29.v.75 : 6/9.vi.75 : 30.x.75 : 31.xi.75 : 12.iv.76 : 16.iv.76: 6.v.76 : 12.v.76 : 18.v.76 : 7/8.vi.76 : 10.vi.76: 12/15.vi.76 : 11.vii.76 : 3.xi.76:18.xi.76:29.iii.77: 21.iv.77 : 30.iv.77 : 21.v.77 : 23.v.77 : 25.v.77.

Leucostrophus hirundo Gerst. — 5.iv.67:3.iii.68: 4/8.xi.73 : 4.xii.73 : 23/24.ii.77. Migrations of this species often accompany those of *Cephonodes hylas* L.

Hyles lineata L., *livornica* Esp.—10.v.61:21.iv.69: 8.iv.75 : 15.iv.75 : 4.v.75 : 15/16.v.75:31.v.75: 9.xii.75 : 24.iv.77. This well known migrant is only an occasional visitor to the Kenya coast and usually occurs as singletons.

Hippotion celerio L.—7.iv.63 : 21.i.66 : 27.iv.68: 11/24.x.69 : 29/31.iii.69 : 8.iv/3.v.69 : 5/7.iii.70: 29.iv/7.v.70 : 29.v./6.vi.70:16.xi.70 : 23/24.iii.71: 31.iii/3.iv.71 : 6/9.iv.71 : 28.iv/4.v.71 : 21.iii.72: 24/27.iii.72:18/20.iv.72 : 8/11.v.72 : 13/16.v.72: 4.iv.73 : 24/29.iv.73 : 11.v.73 : 14.v.73 : 24/26.vi.73 : 14.xi.73 : 1.iv.74 : 5.iv/31.v.74 : 10/15.xi.74 : 5/15.iv.75 : 17/22.iv.75 : 28.iv.75 : 3/26.v.75 : 11.iv.76 : 16.iv.76 : 18.iv.76:20.iv/2.v.76 : 11.v.76 : 16/22.v.76 : 24.v.76 : 26/28.v.76 : 30.v.76 : 1.vi.76 : 3/9.vi.76 : 14.vi.76: 16/28.vi.76 : 30.vi/1.vii.76 : 6/7.vii.76:9/10.vii.76: 16.vii.76 : 19/22.vii.76 : 27/28.vii.76 : 3.viii.76: 12.viii.76 : 16.viii.76 : 21/22.viii.76:24/25.viii.76: 28.viii.76 : 21.iii.77 : 26.iii.77 : 29/30.iii.77 :

1.iv.77 : 6.iv.77 : 9/11.iv.77 : 14/15.iv.77 : 17/21.iv.77 : 23.iv/1.v.77 : 6.v.77 : 11/13.v.77 : 16.v.77 : 18/25.v.77. Migrants can be distinguished from locally bred specimens by being rather larger. Migrations of *H. celerio* are usually accompanied by fair numbers of *H. eson* Cr. and occasional *H. osiris* Dalm.

Centroctenema imitans Btlr. — Singletons occur rarely throughout the year, but on 7/8.xi.64 and 14/15.xi.66 comparatively large numbers visited the lamp.

URANIIDAE and THAUMETOPOEIDAE — Neither of these two families has shown any sign of migratory activity.

NOTODONTIDAE — No member of this family has given any indication of being a migrant with the following exception. In October 1972, a few larvae of *Simesea orestes* Kiriakoff were found feeding on *Terminalia catappa* (Combretaceae) in my garden, and a few imagines visited the lamp the following month. This is the only occasion when the species has appeared.

MEGALLOPYGIDAE — I have not found any member of this family on the Kenya coast.

LIMACODIDAE, CHRYSOPOLOMIDAE, PSYCHIDAE, THYRIDIDAE, METARBELIDAE, AEGERIIDAE and COSSIDAE — No member of any of these families has shown any sign of migratory activity.

AGARISTIDAE — Members of this family are not usually migrants, the normal pattern is for occasional singletons to visit the lamp, but in 1975 there was distinct evidence of migration. On 10.iv.75 considerable numbers of *Aegocera trimeni* Feld., including a few specimens of the white hind-winged form, not seen previously, visited the lamp and continued in some numbers until 19.iv.75. On 17.iv.75 a single specimen of *Schausia daria* Druce, a species not seen before or since, appeared, and on 5.v.75 large numbers of *Schausia coryndoni* Roths., normally a rare species, came to the lamp and continued, sometimes in uncountable numbers, until 23.v.75. During this period, the species swarmed at Lantana flowers in the Shimba Hills.

NOCTUIDAE — A number of species, belonging to different sub-families, have been recorded as migrating.

Cirphis loreyi Dup. — Normally an occasional visitor to the lamp, but occurred in considerable numbers on 23/28.v.62. Recorded as a migrant in Europe.

Spodoptera exempta Wlk. — 13/15.iii.61 : 2.xii.63 : 17.vii.65 : 13/15.xii.65 : 15/20.xi.66: 29.xi/4.xii.66 : 3/5.v.70 : 17/30.xi.70 : 24/27.xi.72 : 23.iii.74 : 20.iv.74 : 31.iii.75 : 20.iv.75: 23/24.ii.77 : 16/18.iv.77 : 20.iv.77 : 26.iv.77. Apparently not a resident species.

Euterpioides spec. nov., nr. *pienaari* Dist—Has occurred on three occasions, viz. 9/10.xii.64: 9/10.iv.65 and 31.iii.75, on all occasions in some numbers.

Ilattia octo Guen. — The local population is periodically re-inforced by migration. 2/4.i.65: 6/7.iv.67 : 28.ii.68 : 16/18.xi.70 : 17/18.ii.73.

Amyna punctum F. — A major migrant, the varying proportions of the nomino-typical form and f. *spoliata* Wlk. indicating different origins for the flights: 13/17.iv.59 : 20/24.xii.62 : 27.xii.62 : 29.xii.62 : 10.i.63 : 2/4.i.65 : 21/23.iii.65 : 3/4.iv.65 : 17.iii.66 : 6/8.iv.66 : 17/20.v.66 : 21.x.67 : 24/25.x.67 : 28.ii.68 : 1.iii.68: 20.iii.68 : 23/26.iii.68 : 29.iii.68 : 18.v.68 : 14/18.iii.69 : 24/31.iii.69 : 9/29.iv.69 : 2/5.v.69 : 12/13.ii.70 : 15/19.iii.70 : 21/28.iii.70 : 30.iii/1.iv.70 : 3.iv.70 : 5/6.iv.70 : 8/9.iv.70 : 21/22.iv.70 : 29.iv/5.v.70 : 23/27.iii.71 : 30.iii/4.iv.71 : 7/9.iv.71 : 17/24.iv.71 : 20/21.iii.72 : 24.iii.72 : 7/8.iv.72 : 14/20.iv.72 : 8/15.v.72 : 24/27.xi.72 : 17/18.ii.73 : 25.iii.73 : 3/4.iv.73: 18/20.iv.73 : 27/29.iv.73 : 24/26.vi.73 : 11/12.xii.73 : 22/26.iii.74 : 31.iii/2.iv.74 : 9/16.iv.74: 20.iv.74 : 24/30.iv.74 : 2.v.74 : 10/13.v.74 : 19/20.v.74 : 31.iii/18.iv.75 : 21/24.iv.75 : 30.iv/24.v.75 : 24/25.iii.76 : 6.iv.76 : 9.iv/1.v.76 : 7/8.v.76 : 11/12.v.76 : 19.v.76 : 8/9.vi.76 : 14.vi.76 : 16/17.vi.76 : 23/24.ii.77 : 17/18.iii.77: 21.iii.77 : 23/27.iii.77 : 29.iii.77 : 9/11.iv.77 :

14.iv.77 : 16.iv.77 : 18/27.iv.77 : 29.iv.77 : 6/8.v.77 : 21/23.v.77.

Blenina quadripuncta Hamps. — A fairly regular migrant. 21/24.xii.62 : 27.xii.62 : 29.xii.72 : 2/4.i.65 : 3/4.iv.65 : 17/18.iv.65 : 3/5.xii.65 : 17.iii.66 : 21.x.67 : 24/25.x.67 : 16.iii.68 : 14/18.iii.69 : 29/30.iii.69 : 9/11.iv.69 : 13/15.iv.69: 18/22.iv.69 : 26/29.iv.69 : 2/5.v.69 : 29.xi/8.xii.69 : 10/24.xii.69 : 16/17.iii.70 : 27.iii/3.iv.70 : 5/8.iv.70 : 24.iii/3.iv.71 : 7/9.iv.71 : 20/21.iii.72 : 24.iii.72 : 7/8.iv.72 : 18/20.iv.72: 24/27.xi.72 : 25.iii.73 : 3/4.iv.73 : 7/9.xii.73 : 1/2.iv.74 : 2.v.74 : 25.v.74 : 30.iii/18.iv.75 : 21/24.iv.75 : 2/24.v.75 : 23/25.iii.76 : 9.iv.76: 12.iv.76 : 17/18.v.76 : 20/25.v.76 : 4/5.vii.76 : 25.iii.77 : 27.iii.77 : 29.iii.77 : 8/11.iv.77:14.iv.77: 25.iv.77 : 27.iv.77 : 6/8.v.77 : 22.v.77.

Chlorozada metaleuca Hamps. — An occasional migrant. 22.iii.68 : 24/25.iii.68 : 27/28.iii.70.

Maurilia arcuata Wlk. — Very occasional migrations augment the local population. 5.vi.71 : 31.v/5.vi.76 : 7/8.vi.76.

Attatha ethiopica Hamps. — Singletons have appeared on four separate occasions, viz.—19.v.75: 1.v.76 : 7.v.77 : 24.v.77.

Cyligramma latona Cr. — A fairly regular migrant. 11.iv.63 : 21/23.iii.65 : 3.iv.65 : 29.xii.65: 6/8.iv.66 : 3/7.iv.67 : 17/18.iv.67 : 17.iii.68 : 20.iii.68 : 29.iii.68 : 5/11.iv.68 : 10.iii.69 : 23/27.iii.69 : 29/30.iii.69 : 13/14.iv.69 : 19.iv.69 : 8.iii.70 : 28.iii.70 : 30.iii/3.iv.70 : 6.iv.70 : 23/28.iii.71 : 30.iii/5.iv.71 : 14.iv.72 : 18/20.iv.72: 25.iii.73 : 27/29.iii.73 : 11/12.xii.73:22/26.iii.74: 31.iii/2.iv.74 : 10/14.iv.74 : 24/26.iv.74 : 30.iii/1.iv.75 : 6/18.iv.75 : 2.v.75 : 4.v.75 : 17.v.75 : 24/26.iii.76 : 6.iv.76 : 15/22.iv.76 : 17/19.iii.77: 21/27.iii.77 : 5/6.iv.77 : 13/15.iv.77 : 21/26.iv.77 : 4.v.77.

Cyligramma fluctuosa Drury — A very occasional migrant. 11.v.63 : 21/22.v.75.

Achaea lienardi Bsd. — A very regular migrant appearing in vast swarms. 14.iii.63 : 23.iii.65 : 17.iii.66 : 6.iv.66 : 20.x.67 : 24/25.x.67:28.ii.68: 1.iii.68 : 20.iii.68 : 22.iii.68 : 30.iii.68:5/11.iv.68: 15/16.iii.70 : 26/28.iii.70 : 30.iii/3.iv.70:29.iv.70: 23.iii/2.iv.71 : 20/21.iii.72 : 24/25.iii.72:3.iv.72: 6/10.iv.72 : 3/4.iv.73 : 23.iii.74 : 1.iv.75 : 7/14.iv.75 : 12.v.75 : 23/26.iii.76 : 16/18.iv.76 : 22.iv.76 : 24/28.iv.76 : 28.x/4.xi.76 : 17/18.iii.77: 21.iii.77 : 25.iii.77 : 27.iii.77 : 5/6.iv.77 : 10/11.iv.77 : 14.iv.77 : 21.iv.77.

Achaea praestans Guen. — Migrations of the previous species almost invariably include a very few specimens of *praestans*. The following are occasions when it has been on its own, 22.iv.74 : 29.iii.77.

Grammodes stolida F. — Occurs rarely all through the year, only twice has it appeared in numbers indicative of a migration. 28.xii.76/1.i.77 : 23/24.ii.77.

Phytometra acuta Wlk. — Always present at the Coast, but sometimes migrates in considerable numbers. 21/24.xii.62 : 27.xii.62 : 29.xii.62 : 29.xi/6.xii.65 : 17.iii.66 : 19.iv.69 : 21.iv.69 : 24/29.xi.70 : 27.iii.70 : 30.iii/4.iv.71 : 15/16.iv.72 : 18/20.iv.72 : 3/4.iv.73 : 17/18.xi.73: 20/26.iv.74 : 6/18.iv.75 : 21/25.iv.75 : 2/24.v.75: 1.iv.76 : 10/15.iv.76 : 18/20.iv.76 : 22/24.iv.76: 26/30.iv.76 : 4.v.76 : 7/8.v.76 : 10/15.v.76:19/23.v.76 : 23/24.ii.77 : 29.iii.77 : 11.iv.77:24.iv.77.

Phytometra limbirena Guen. — A singleton on 15.xi.66. Presumably a vagrant from upcountry.

Sphingomorpha chlorea Cr. — Occurs occasionally all through the year, rarely appearing in numbers indicative of a migration. 6.iv.63 : 31.iii.71 : 2.iv.71.

Calesia zambesita Wlk. — A fairly regular migrant from upcountry. 27/29.iv.70 : 2/3.v.70: 28/29.xi.70 : 23/27.iii.71 : 10.v.72 : 24/27.xi.72: 9/12.iv.75 : 15/18.iv.75 : 6/8.v.75 : 25.iii.76 : 7.v.76 : 11.iv.77 : 20.iv.77 : 24/25.iv.77.

Anomis sabulifera Guen. — Present all through the year, sometimes appearing in larger numbers, presumably the result of migration. 20/24.xii.62: 27.xii.62 : 29.xii.62 : 29.xi./6.xii.65 : 28.xi/1.xii.66 : 10.iii.67 : 5/7.iv.67 : 12/13.iii.70 : 16/19.xi.70 : 27/29.xi.70 : 24/27.xi.72 : 4/6.xii.73.

Plecoptera hypoxantha Hamps. — Present all through the year, but has recently given indications of migratory activity. 17/23.iv.71 : 20/22.iii.72 : 22/30.iv.74 : 24/27.vi.74 : 26/27.iv.75: 30.iv/3.v.75 : 7/24.v.75 : 12/14.iv.76 : 16/17.iv.76 : 19/22.iv.76 : 7/8.v.76 : 11/12.v.76 : 18/19.v.76 : 2/4.xii.76.

Bomolocha jussalis Wlk. — An occasional migrant. 6/7.iv.67 : 16/18.xi.70.

Bomolocha obsitalis Wik. — A more frequent migrant than the previous species. 21/24.xii.62: 27.xii.62 : 29.xii.62 : 16/18.xi.70 : 27/28.xi.70: 24/27.iii.71 : 7/8.iv.72 : 18/19.iv.73 : 23.xi.73: 20.xi.74 : 15/18.iv.75.

Hyblaea euryzona Prout — A fairly regular migrant. 11.iv.62 : 18/22.iv.62 : 21/23.iii.65 : 3/4.iv.65 : 17/18.iv.65 : 20.iv.65 : 3/6.iv.66 : 15/17.iv.67 : 22.iv.67 : 20.iii.68 : 12.iv.68 : 20/22.iv.70 : 31.iii/1.iv.71 : 7/9.iv.71 : 27.iv.72 : 1.iv.74 : 9.iv.74 : 30.iii.75 : 12.iv.76.

Hyblaea flavipicta Hamps. — Often associated with the previous species. 11.iv.62 : 18/22.iv.62: 12/14.iv.63 : 2/4.i.65 : 21/23.iii.65 : 3.iv. 65 : 17/18.iv.65 : 20.iv.65 : 3/6.iv.66 : 15/17.iv.67: 22.iv.67 : 12.iv.68 : 1.iv.70 : 9.iv.74 : 2.v.74 : 8/18.iv.75 : 21/28.iv.75 : 8/10.v.75 : 11/13.iv.76: 15/16.iv.76 : 21.iv/2.v.76 : 11/13.v.76 : 20/21.iv.77 : 23.iv.77 : 25.iv.77.

GEOMETRIDAE — There is no evidence of any sort of mass migration in this family. Two species have produced singletons at widely separated intervals, namely—*Euexia percnopus* Prout on 8.iv.56, 25.iv.57, 6.xii.57, and 24.iii.68 and *Neopitthea pringlei* Carc. on 14.i.66 and 22.xi.69.

PYRALIDAE — Four species of this family have been found to migrate.

Macalla sp. — 1.iii.68 : 16.iii.68. The British Museum (Natural History) consider it to be an underscribed species.

Hymenia recurvalis F. — 20/24.xii.62 : 27.xii.62 : 29.xii.62 : 2/4.i.65 : 29.xi./2.xii.66 : 6/7.iv.67 : 29/30.iii.69 : 30.iv/1.v.69 : 14/17.xi.70 : 17/18.ii.73 : 18/19.iv.76.

Marasmia trapezalis Guen. — 13/14.iv.59 : 17.iii.66 : 25/27.iii.69.

Margaronia unionalis Hbn. — 20/24.xii.62 : 27.xii.62 : 29.xii.62 : 2/4.i.65 : 17/18.vii.65 : 1.iii.68 : 11.iv.69 : 13/15.iv.69 : 19.iv.69 : 21.iv.69 : 28.iii.70 : 23/27.iii.71 : 30.iii/1.iv.71 : 12/13.v.73 : 10/13.v.74 : 19/20.v.74 : 1.iv.75 : 6/18.iv.75 : 21/26.iv.75 : 8/24.v.75 : 9.iv.76 : 11/12.iv.76 : 14.iv.76 : 30.iv.76 : 4/8.v.76 : 11/15.v.76 : 18/24.v.76 : 9/11.iv.77 : 24/25.iv.77.

P.S.: Since completing this paper, the Mombasa district has experienced a spell of unprecedented wet weather. Between the 16th September and 18th October 1977, normally a fairly dry period, rainfall of only a fraction short of 10″ has been recorded. This has resulted in exceptional migratory flights.

The two Arctiids, *Digama aganais* Feld. and *D. africana* Swinh., appeared in small numbers between 18/20.ix.77, neither species has previously been recorded in September. Most of the regular Sphingid migrants—*Agrius convolvuli* L., *Pemba favillacea* Wlk., *Poliana witgensi* Strd., *Daphnis nerii* L., *Nephele argentifera* Wlk., *Atemnora westermanni* Bsd. and *Hippotion celerio* L., appeared spasmodically over the whole period, usually in ones and twos, but unaccompanied by their usual migratory companions *Nephele funebris* F., *N. comma* Hpffr., *N. bipartita* Btlr. and *Hippotion eson* Cr.

Amongst the Noctuids, *Amyna punctum* F. and *Blenina quadripunctata* Hamps. occurred in fair numbers between 18/20.ix.77, whilst *Achaea lienardi* Bsd. appeared in vast swarms between 16/23.ix.77, accompanied, as usual, by occasional *A. praestans* Mab.

During this period, the usual resident species occurred in their usual numbers, both when compared with previous years and with the immediate preceding period.

MICROARTHROPODS AND SOIL ECOSYSTEMS

T. N. ANANTHAKRISHNAN[1]

The decisive influence of soil microarthropods, not to mention of other invertebrates in the establishment of diverse patterns in the decomposition of organic matter and the succession of fauna therein involved cannot be underestimated. Results achieved in this direction in many countries sufficiently indicate the need for active cooperation between soil biological and pedological research in determining the fertility of the soils. It is being increasingly realised that many soil microarthropods play a useful role as indicator organisms in relation to soil fertility. The contributions made in edaphic studies through the publications of monographs and books by Kubiena (1955), Haarlov (1960), Nielsen (1955), Kuhnelt (1961), Gisin (1952), Doeksen and Van der Drift (1963) in Europe, Murphy (1955), Kevan (1955), Macfadyen (1962), Edwards (1962), Burgess and Raw (1967), Wallwork (1970, 1976) in England and Morikawa (1957) and Yosii (1955) in Japan are among the most outstanding and a beginning has been made over the last decade in this direction in India as well. With its variety of soil and climate excellent opportunities exist for extensive soil faunal studies particularly with reference to their population dynamics, vertical migrations and a possible correlation of abundance of certain indicator species with soil fertility.

The soil is a complex of physico-chemical and biotic factors and the great diversity of organisms found therein, combined with the physical difficulties of studying them, not to mention the patient, laborious and time consuming task of isolation and identification of the multitude of forms are no doubt factors responsible for the slow progress of this science in this country. All the same one cannot ignore the importance of ecological problems pertaining to the soil, an investigation into which may demand a preliminary exploratory work involving qualitative studies or an inquiry concerning the relative abundance of a wide range of species over a wide range of habitats or the determination of the absolute abundance of some species in a single habitat. Investigations on the edaphic community may lead to the discovery of "life-forms" or "lebens-formen", so characteristic of the soil dwelling Collembola wherein we come across similar modifications even within diverse forms according to the depth or layers of edaphon they inhabit. Thus for example, *Tullbergia, Isotomodes, Folsomides,* etc. are euedaphic living in the depth of soil. All of them are Characterised by their elongate body facies small size (at most 1 mm long), similar segmentation, musculature and easily flexible non-pigmented or feebly pigmented bodies, reduction or the total absence of ocelli and with short and simple hairs and smaller appendages. *Brachystomella, Hypogastrura, Friesea,* etc. are hemiedaphic, including forms living on water surface (neustonic), moss, bark or lichens (xeromorphic) characterised by moderately long antennae, well developed pigment and ocelli. Epigeic forms (living on vegetation or upper surface of litter, combining both hyperedaphic and epiedaphic forms) are characterised generally by eight ocelli, well developed pigmentation, long antennae and furcula, e.g., *Orchesella, Bourletiella, Callyntrura,* etc. In addition are the Troglomorphs (e.g., *Cyphyoderopsis, Trogolaphysa,* etc.), characterised by the absence of ocelli and pigment, long antennae and modified unguis and Synecomorphs living in the nests of ants and termites, characterised by the absence of ocelli and pigment (cf. Troglomorphs), modified mouth parts, well developed furcula and legs and the development of unusual scales and setae (e.g. *Delamarerus, Pseudocyphoderus, Calobatinus,* etc.). Even among cryptostigmatid mites life forms exist, the hemiedaphic forms often showing further modifications in relation to their subdivision into hygrophilous, mesophilous, xerophilous conditions and incidental correlation of the form of the pseudostigmatic organ with the moisture gradient of the environment. Marked specialisation for inhabiting particular depths and associated morphological adaptations are shown by the geophilids, symphylids, pauropods and other microarthropods and such microhabitats within a major community have also been termed '*synusia*'.

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Preliminary qualitative studies on the composition of the microarthropods inhabiting the surface litter (L layer), decaying organic matter (F layer), pasture soil and manured soil are essential aspects of soil microarthropod investigations. Murphy's classification of the fauna into the microfauna (.001-1 mm), meiofauna (0.1-1.6 mm) and the macrofauna (1.6 to several mm) appears a useful measure, the majority of the meiofauna lying at the 3-4 cm level, of which a good number occur in the F layer, 1-2 cm below the surface. In pasture soil, F layer is absent due to the fact that the rate of the decomposition at the surface is sufficiently high to prevent its formation and this kind of soil is usually with a low humus content; during the rainy season, soluble bases are leached out; during the dry season iron and aluminium compounds are oxidised giving the soil a characteristic red or yellow colour. These soils are more correctly called "Latosols" or "Feralitic soils". The dominant microarthropods are the Collembola, mites, symphylids and to some extent the pauropods thrive well in the upper layers. Below this in the mineral soil, the microcaverns or pore spaces are not suitable for the existence of all microarthropods in addition to the absence of sufficient organic matter. Therefore there is a preponderence of these dominant microarthropods in the upper layer of soil and particularly during the hotter months when there is a danger of exposure of the litter to strong sunlight, the fauna migrate to the lower layers. As such the principal factors inducing the vertical migration are the nature of the microcaverns, food, temperature, humidity and predation at the surface. Many symphylids like *Scutigerella* sp., *Symphylella* sp., *Symphylellopsis* sp. show seasonal vertical migrations in soil in response to soil temperature and moisture. Such vertical migrations are also known to occur in response to feeding, moulting and reproductive cycles (Ovipositional). This is also the case with mites and collembola and even the possibility of a diurnal rhythm in vertical movements has been suggested.

Data regarding the vertical migration of microarthropods in Indian soils are very meagre. However Choudhuri & Roy (1971), in their studies on the vertical distribution of some species of Collembola in the gangetic alluvium, observed that *Sphaeridia, Proisoto-*

ma, Alloscopus, Isotomurus and *Sminthurinus* were all more concentrated in the middle layer (5-10 cm), while the maximum number of individuals of *Seira* occurred in the lower layer (10-15 cm).

Symphylids and pauropods are noticeably absent from the L layer (though mites are more abundant), while their number is very meagre in the F layer below it. They are in sufficiently large numbers in the pasture soil and manured soil as has been observed in banana plantation soils. The Collembola of the 'L' layer such as *Callyntrura, Lepidocyrtus, Entomobrya, Isotoma, Salina* and *Dicranocentrides* are large sized, pigmented, with well developed eyes and spring and extremely active and can often be seen to penetrate the soil to a limited extent, while those in the F layer are totally different, being small, slender, unpigmented with reduced eyes and spring as in *Tullbergia, Onychiurus, Xenylla, Isotomodes, Folsomina, Folsomides* and *Folsomia* which move along the walls of the soil microcaverns. The most important single factor governing the distribution of Collembola is moisture and the possibility of the Collembola acting as indicators of soil water condition has been suggested. In other words the water content of the soil could reflect the species composition of the population. For instance, the mesophil fauna such species of Collembola as *Folsomia brevicauda, Friesea mirabilis, Isotoma sensibilis* occur, as against the only Xerophil species *Tetracanthella wahlgreni* (Hale 1963). The mite fauna are present both in the L and F layers in considerable numbers, the Oreibatid mites being more abundant in the L layer than the F layer. The Tyroglyphid and Tetranychid mites however are generally recorded only in meagre numbers. Some of the dominant species of soil mites, collembola etc. characteristic of grassland, forest and cultivated soils from India are represented in Table I.

Considerable specificity of microarthropods, particularly amongs the collembola exists in accordance with the different ecotopes. Mitra, *et al.* (1977) observed the specificity of Collembolan species in accordance with six ecotopes (including five vegetational sites) at the Eden gardens, Calcutta. The existence of both qualitative and quantitative population differences in three sites, viz., forest, new clearing and tea fields and the total absence of the litterine genera of Collembola like *Lobella, Lepidocyrtus, Dicranocentrus, Callyntrura, Salina, Dicyrtoma,* etc. at the newly cleared sites, were indicated by Prabhoo (1976) who also observed a similarity of fauna in the forest and tea field soils.

The species composition of the litter may be said to indicate the soil edaphon of the future, because on the litter fauna depends the widely varying degree of decomposition necessary for the enrichment of the soil. It provides a typical instance of what can be called a metabiotic process wherein one series of organisms provide favourable conditions for the next. The role of Collembola in the initial break down of litter followed by the millipedes and the earthworms is well known. They are known to actively remove material, ingesting them into the gut and produce faecal pellets which are added to the soil, thereby providing readily available material to the decomposers. The mechanical effect of the breakdown of litter by the millipedes is enormous and as a result of frequent migrations up and down the soil profile, they are said to effect a mixing up of the mineral and organic portions of the soil. Under neutral and slightly alkaline conditions, the millipedes, isopods and annelids establish themselves and play an important role in modifying and mixing the surface litter with the lower horizons of the soil. Under acid conditions such species are inhibited and mites, dipteran larvae and Collembola typify the fauna which do not significantly change the character of the horizon. It was on the basis of the millipede, isopod and insect larval activity in the soil that Kubiena (1955) introduced the 'moder' and 'mull-like moder' concepts of the humus forms according to which forms inhabiting sandy, base deficient soils constitute the moder species (mites, collembolans and insect larvae), while the base rich clayey soils form the 'mull-like moder' species of which the millipedes form the largest proportion followed by enriched earthworm and isopod population. However the actual number, the biomass and relative efficiency of each group is dependant more upon the basic features of the soil as mentioned above, as well as of the diverse factors which tend to modify the soil environment. It is because of such variable interactions that reliable estimates pinpointing the effective role of each group of soil animals have not been possible, though in general it has been estimated that animals consume 10-20% of the total organic matter supplied to the soil. A moderate temperature and moisture, with the availability of decaying organic matter on the soil surface constitute the optimal conditions for the growth and multiplication of such microarthropods as symphylids. To cite an example, at a temperature of 36°C and 65% RH the average population of *Symphylella* sp. for 110 c. of soil was 420, while at temperatures of 29-32°C and 86-90% R.H. the average population was found to be 2935 and in between these ranges of temperature and humidity the population range was 1194-2080 individuals. (Ananthasubramanian & Ananthakrishnan 1962). The study of the abundance of the microarthropods in a variety of soils is considered significant because it is seen that fertilising the soil with organic manure increases the edaphic composition tremendously, in particular the collembolans and the symphylids. The Collembola are very abundant in the surface manure and helps in its decomposition after which, the manure fauna changes into a true soil fauna through the compost fauna. It has been estimated that the collembolan fauna of compost is 1,30,000 per metre^2 surface upto a depth of 10 cm.

The forest floor in Tropical forests provides a good example of surface litter zones Ananthakrishnan (1973) has sufficiently emphasised this aspect in relation to mycophagous thrips. In litter, thrips are usually confined to the uppermost layer on entire leaves, and in the lower layers are mites, collembola, beetles etc. and only a few thrips. Leaf litter provides a more or less uniform semipermanent habitat and thrips are never common in wet litter and are abundant in litter resulting from diverse tree and shrub flora which are very characteristic of the Western Ghats. The movement of microarthropods between the different horizons of the mineral soil and litter is influenced by the graded series of relative humidities. Species of Cryptostigmatid mites of the fauna *Steganacarus, Oppia, Platynothrus, Adoristes* etc., mesostigmatid species of *Trachytes*, the predatory *Pergamasus, Macrocheles* sp. are more common in surface litter. Assessment of the relative efficiency of each group of organisms in term of litter decomposition is a difficult problem since animal activities may alter litter in such a way as to effect the species composition.

The major contributors to the litter in such forest areas as of the Western ghats involve species of *Mesua* (Guttiferae), *Ternstroemia* (Ternstroemiaceae), *Dipterocarpus* (Dipterocarpaceae), *Pterospermum* (Sterculiaceae),

TABLE 1

SOME DOMINANT MICROARTHROPODS IN GRASSLAND, FOREST AND CULTIVATED SOILS IN INDIA

SOIL MICROARTHROPODS	GRASSLAND	FOREST	CULTIVATED SOIL
COLLEMBOLA	*Lepidocyrtus suborientalis*	*Lepidocyrtus* (*Acrocyrtus*) sp.	*Isotomina thermophila*
	Cyphodersus albinus	*Cyphoderus javanus*	*Xenylla* sp.
	Megalothorax minimus	*Brachystomella* sp.	*Proisotoma* sp.
	Folsomides parvulus	*Lobella siva*	*Megalothorax* sp.
	Isotomina thermophila	*Folsomides exiguas*	*Folsomides* sp.
	Arrhopalites sp.	*Sminthurus* sp.	*Pseudosinella* sp.
	Pseudosinella sp.	*Sminthurides* sp.	*Isotomurus* sp.
	Sphaeridia sp.	*Isotomina interrupta*	*Folsomina* sp.
	Isotomurus ciliatus		
	Isotomiella minor		
	Sminthurus sp.		
	Brachystomella curvula		
	Pseudochorutes sp.		
	Tullbergia sp.		
	Salina bengalensis		
	Lobella maxillaris		
ACARINA	*Laeioseius reticulatus*	*Hypoaspis miles*	*Scheloribates* spp.
	Papillacarus indicus	*Scheloribates* spp.	*Oppia* sp.
	Epilohmannia pallida	*Epilohmannia* sp.	*Rhysotritia* sp.
	Archegozetes magna indicus	*Scutacarus vestigialis*	*Gamasodes assamensis*
	Allonothrus indicus		*Lamellibates bengalensis*
	Scheloribates spp.	*Scutacarus tackei*	
	Rhysotritia sp.	*Scutacarus hamatus*	
	Hypoaspis bengalensis	*Imparipes longisetosus*	
	Macrocheles hyatti	*Pygmephorus spinosus*	
	Gamasodes assamensis	*Bakerdania kashmirensis*	
	Allothrombium australiense		
	Oppia spp.		
	Holostaspella parornata		

DIPLURA	*Parajapyx grassianus indica* *Japyx indicus* *Indjapyx pruthii* *Lepidocampa gravelyi*	*Lepidocampa (Lepidocampa)* *Juradii bengalensis* *Japyx* spp.	—
PROTURA	*Acerentomon* sp. *Eosentomon* sp. *Protentomon* sp.	*Acerentomon* sp. *Eosentomon* sp.	—
SYMPHYLIDS	*Scutigerella* sp. *Symphylella* sp. *Symphylellopsis* sp.	*Symphylellopsis* sp. *Symphylella* sp. *Scutigerella* sp.	*Scutigerella immaculata*

Pterocarpus (Leguminosae), *Terminalia* (Combretaceae), *Syzigium* (Myrtaceae) *Barringtonia* sp. (Lecythidaceae), *Tectona* (Verbenaceae), *Dalbergia* (Leguminosae), *Mallotus* (Euphorbiaceae), *Lagerstroemia* (Lauraceae), *Kigelia* etc. (Bignoniaceae). Many Tubuliferan thrips species inhabit this fungus infested litter and these mycophagous species are important members of this specialised niche. The dominant species inhabiting the litter are *Gastrothrips karnyi, Nesidothrips alius, Kleothrips gigans, Elaphrothrips productus, Hoplandrothrips flavipes, Hoplothrips fungosus, Diceratothrips usitatus, Nanothrips parviceps, Azaleothrips amabilis* and *Stigmothrips limpidius.* Ananthakrishnan (1973) provides a detailed account of the various species inhabiting the saprophytic fungal zone. The conspicuous polymorphism in leaf production and the constant non-synchronus leaf fall make available abundant litter which provides an ideal microenvironment constituting a saprophytic fungal zone. The destruction of forests naturally limits litter production and interferes with the process of litter decomposition through the agency of micro-orthropods.

Therefore, regular examination of the litter and F layers in a variety of habitats should reveal an ever increasing and abundant population of diverse microarthropods which should be correlated with the nature of the litter and in view of the largely saprophagous and fungal feeding habits there is ample scope for research into the role of these fauna in the sequential breakdown of organic mattter as well the changes in the fauna such as the Collembola and mites associated with plant succession. Further the catalytic action of the animals on soil metabolism appears to be a new line of investigation, the dead bodies, exuviae and most important of all the faecal matter of soil animals providing enriched sites for other organisms in the process of development of mature soils.

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THE CHANGING WILDLIFE OF KATHIAWAR

K. S. DHARMAKUMARSINHJI[1]

(*With four plates*)

In this Jubilee *Journal* I intend to review some of the changes I have seen in wildlife of Kathiawar since my early days and give importance to some of my reminiscences and interesting happenings I have noted in the past almost fifty years. Kathiawar in Western India was unique in having most of the peninsula under the rule of Princes of which the three largest states were, Junagadh, Nawanagar and Bhavnagar having territories of over 2800 sq. miles. The Baroda State had enclaves in Amreli and Okhamandal and many states had isolated villages scattered throughout Kathiawar. British India lands were also woven into this fabric of Princely states with the British Agent placed at Rajkot. Some of the states had their Military and separate Judiciary. I shall not go into details of administration but all Princes had the prerogative rights of hunting in their own states. These rulers maintained a Shikar department or staff, thus shikar (all type of hunting) was a part and parcel of the Princely Order in which the State Administrators (Dewans) normally did not interfere. Although most princes enjoyed shikar not all indulged in it. Nevertheless, wildlife, specially game species were jealously guarded, not always under legislation but under rules of game management. The unwritten code was that no animal life should be killed without permission of the ruler and that the game habitat should be totally protected even against cutting of roadside trees. The shikar-cum-forest departments existed in the larger states and since the Junagadh state had the largest forest in the Gir and Girnar, it commenced to employ a qualified retired Forest Officer and roads were made to exploit teak and miscellaneous dry deciduous and bamboo forests. But the main importance of the Gir was for the protection of the vanishing Asiatic lion, its prey and its habitat.

From 1928 to 1938 the position of wildlife in Kathiawar was of tremendous interest. In 1928 I had returned from England after schooling, in which country I knew more about British birds than those of India. The impact on me of seeing an immense number of birds and game animals in Kathiawar was tremendous and I started game shooting in earnest. Bird life in Kathiawar was abundant and more trusting than what I had seen in England and I was interested in identification. My early recollection of seeing the now extinct Grey Hornbill in Gir forest revealed to me the new type of bird life of India. My earliest sighting of the great Indian bustard was when a '*Vaghari*', one of my late father's trappers, brought a bird during the monsoon for the Palace table. Even before my father's time this bird was considered a delicacy by many princes in India. I had enquired about the trapped bird and was told that it could not survive in captivity, but I think no attempt was made, and the bird found its way to the kitchen. Later when my brother became the ruler, he put a stop to the practice and no more bustards were snared thereafter. To me as a young boy large birds stood out conspicuously, and among these the Sarus Crane and the Bustard impressed

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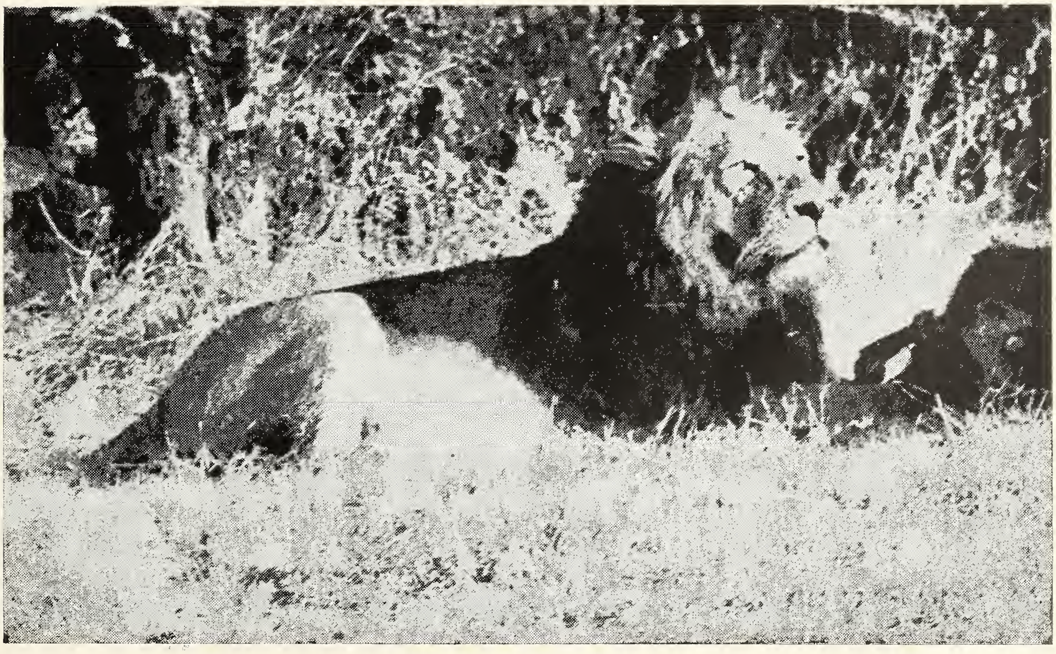
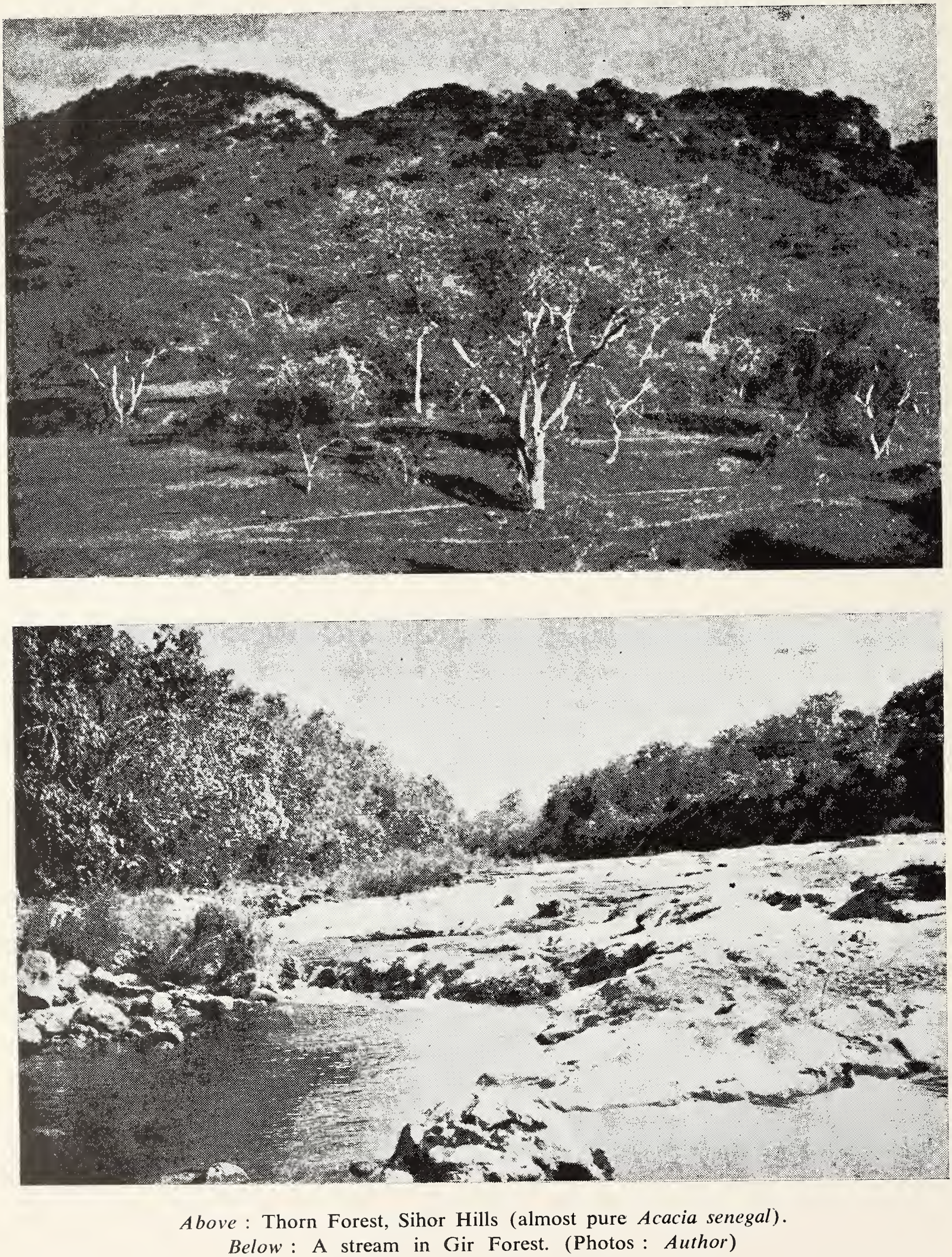


Above : Girnar (north aspect).
Below : Asiatic Lion—Gir Forest. (Photos : *Author*)



Above : Thorn Forest, Sihor Hills (almost pure *Acacia senegal*).
Below : A stream in Gir Forest. (Photos : *Author*)

me most. The then Dhrangadhra Ruler had the largest and best preserve of the *'Ghorad'* (great Indian bustard) and he had made rules to inflict heavy penalties on those who killed this bird. Many states had grasslands where this grand bird was found, infact it was found all over Kathiawar, except the Gir, Girnar, Barda and smaller hill forests. Large tracts of grasslands, some of it ideal savanna were seen in Okhamandal, Junagadh, Nawanagar, Bhavnagar, Jasdan, Wadhwan, Rajkot, Virpur, Bagasra, Bhadwas Wankaner, Morvi and smaller owners of *"Vidis"* (grasslands), also contained bustards at various times of the year.

In many of these areas during the monsoon season the lesser florican (*Khad-Mor*) was seen frequently but was unfortunately shot indiscriminately during the breeding season. The conspicuous pied males were the most shot.

The Princes of Kathiawar were a hospitable lot, and many were most generous and by and large, big and small rulers offered shikar whenever we visited them. At home, I had the singular advantage of learning more about game birds from the Fauna volumes by E. C. Stuart-Baker, and from listening to old shikaries including some of my father's contemporaries and from an Englishman who had been Vice-President of the Bhavnagar State Minority Administration Council, Mr. A. H. E. Mosse, who was a Sportsman who had not only shot big game in Somaliland, Africa, but also had considerable experience in India and was a noted Lepidopterist. When I identified the first Marbled Teal, a rather rare species of duck in Kathiawar in a Duck Bag, Mosse was surprised, and congratulated me and gave me encouragement. Since then I had always made it a point to examine all ducks shot. In those days, 1928 to 1938, there were not many large tanks in Kathiawar and I recollect that the winters were colder and the hot weather more severe. The cold winters attracted huge masses of waterfowl and these were unmolested in the small village tanks until a few weeks in winter when duck shooting was in vogue, but most tanks were left untouched. In the well-known duck tanks, the ducks were abundant and Shoveller, Pintail, Pochard and Teal were conspicuous, Coots were almost in equal numbers, if not more, in the larger tanks. Most princes encouraged by Englishmen, indulged in organizing 'Duck Shoots'. The best shoots I have seen were those organized by Maharaja Raj Saheb Shri Ghanshyamsinhji of Dhrangadhra, who could tell every species on the wing and who was a jovial hospitable host. Maharaja Maharana Raj Saheb of Wankaner, Shri Amarsinhji, who had some of the best 'Jheels' for ducks arranged duck shoots on a grand scale. Both the States were in Jhalawar prant in N. E. Kathiawar.

A famous 'Jheel' nearer than Lakhtar for duck was Chandrelia where the real big shoots were organized. In earlier times Maharaja Ranjitsinhji, the Jam Saheb of Nawanagar the famous Indian Cricketer-Administrator organised duck-shoots in which early records of the Common Sheldrake, Greylag Geese and other birds were shot near Balambha on the northern Kathiawar border. I was a young boy of 12 when I shot my first duck, a shoveller drake in the duck shoots of January 31, 1929 at Wankaner, on the occasion of the marriage of the present Raj Saheb Shri Pratapsinhji of Wankaner. This day was the coldest day I have ever felt in Kathiawar. There was a layer of frost on the pool of the Palace when we went out for the duck shoot wrapped in woollens and overcoats. On the way to the duck jheels I saw a pair of great Indian bustards. At this early age I clearly remember noting some of the duck in the duck bags. Most of these contained Common Teal, Garganey, Shoveller, Common, Tufted and White-Eyed Pochards, Gadwall, Wigeon, and Pintail. I also noticed a few pairs of Mallard, Comb duck and Redcrested Pochard, and realized later how rare the Comb duck was then. Although I did not notice then but Lesser Whistling Teal must have been shot too. Teal and Shoveller were doubtless the most common duck shot followed by Common Pochard.

As small game was so abundant in those days shooting days were many. Most of the shooting was done by organizing beats in which Partridges (Painted & Common Grey), and Hare were the main species shot with a sprinkling of Quails. Sandgrouse was not shot at the waterside but by walking up. No small game was shot from a car. In fact, migratory crane which were seen on the roadside while driving were left untouched as the guns were still in their cases. Walking up cranes is not easy and flight shooting of cranes had not begun, until the fifties, so the cranes had an easy time. Occasionally an Englishman shot the Thick-knee or the Goggle-Eyed Plover for the table. Green Pigeon in South and East Kathiawar where the birds were found, were occasionally shot for the table. In the early thirties I once remember seeing Greylag Geese at Bhavnagar, but these birds could not have been so rare as they are mentioned in the old Kathiawar Gazetteer as being found in the *Gheds,* a type of lagoons in S.W. coastal area: on the Little Rann of Kutch geese have been shot. Snipe shooting was common in some states specially to please the English sportsmen and even birds such as the Painted Snipe (which is really a rail) and the diminutive Jack Snipe were also shot. Large bags of snipe were never made and ten or twenty couple was considered a good bag, with two or three guns. As there was so much scrub and brush cover for small game in fallow land, the need to shoot in 'Wadis' (irrigated farms) was not necessary. Therefore, the countryside was full of small game. Most of the beaters were trained to pick up fallen and wounded game and gun dogs were seldom used. Col. D. S. Bedi, who was District Magistrate at Rajkot always used dogs and was a keen falconer. Later my brother always used gun-dogs. Generally all small game shoots commenced at dawn and ended before breakfast and sometimes before lunch. Whereas, duck shoots started just before or after breakfast. Some of these grand shoots went on the whole day and for days, with breakfast, lunch and tea being served in the butts or at a 'rendezvous' site. When tanks were placed far from each other, ducks returned to them regularly during the shoot. As there were so many ducks in the larger tanks, they got used to gunfire and were reluctant to rise. The cease fire bugle was sounded when most ducks had departed or were flying too high and blown again when the shooting was allowed after most ducks had realighted. When I look back at these duck shoots I feel that they were really a great slaughter in which the birds had no chance of escape except by keeping out of shot range high in the air. When birds did not take wing in the middle of a tank, boats were sent out to flush them. Notwithstanding these, I would not have recognised so easily the ducks in the hand or in flight, but for the duck shoots. Field Guides to Birdwatching had not been invented. In fact most of the so-called birdwatching was in quest of game shooting, in which the shikaries were experts. I learnt to see the squatting hare or Partridge in cover with the help of shikaries and *vagha-*

ries. Later this ability was useful to us when coursing hare with Australian and English greyhounds. From the 1930s onwards I witnessed the best shikar period in Kathiawar and game species seemed abundant and inexhaustible. It was an age of sport in which, Cheetah hunting, Caracal hunting, Falconry, Fox hunting with hounds plus long dogs, Pig-sticking, and game shooting was indulged in. There was never a case of not bagging what one wanted. Blackbuck, Chinkara, Nilgai and Wild Boar were abundantly scattered all over the peninsula and the ubiquitous *Opuntia* and *Euphorbia* (Cacti) afforded ideal cover to small game and even to the wild boar, panther and lion. Pig-sticking was indulged in by Princes and cavalry officers in which I have seen the best of sport. Capt. Ravubha B. Gohel, winner of the Salmon Cup from the Bhavnagar Lancers was as good as any. My brother, (Krishnakumarsinhji) used the spear with great courage and accuracy and he had mastered killing the boar with one spear in the heart, a technique which required great skill. He organized a Zulu Spear Hunt by getting the lancers to surround a sounder of wild pigs and spearing them on foot in which he himself participated. On another occasion when a large 35″ high boar was unyielding to beaters in a sugar cane brake, he dismounted and speared him on foot inside the brake and luckily escaped being gored. The boar was flushed and speared soon after. The Nawanagar and Jasdan Princes also did pig-sticking. Kumar Shri Jiva Khacher of Jasdan being known for his elan in this sport.

Amongst the larger states, Junagadh, perhaps, had the largest number of wild boar in the Gir hills, and boar were abundant on the outskirts of the Gir and Girnar hills. At Mahuva, (Bhavnagar State) I remember seeing sounders of over 500, the master boars gnashing their tusks with foaming mouths and red-shot eyes, raising their crest and displaying side whiskers aggressively when approached. There were at least 2000 to 4000 wild boar in the Coconut-cum-Mango plantation at Ranbag (Mahuva). These animals were a serious cause of grievance to farmers whose crops they ravaged. The Dewan had to intervene and request the ruler to mitigate this evil by reducing their numbers. At one or more occasions, the Military were called to slaughter them, but later owing to the inadequacy of the men and type of arms used, the control measures were taken over by members of our family and friends. I joined these summer parties in which beats were arranged during which animals were shot and speared. Gunning the pigs when resting during day time was also done as was the practice in the Victoria Park, Bhavnagar when pigs were overabundant. Most of the wild boar took refuge in Babul thickets and *Opuntia* hedges. At Dholera, pigs in flat country were found in marshy seacoast as well as in the *Opuntia* clumps whereas in the scrub hills the *Euphorbia* cacti and ravines harboured the most. In Junagadh State, and parts of Barda Hills, the muslim forest guards did not eat pig flesh and so the wild boar increased in huge numbers. In the Hindu States, the Nilgai, was a great nuisance to farmers, as the people considered it a cattle-species and hence it was seldom killed. Nilgai was overabundant in many states and it afforded sport when shooting in the hills or scrubs. In both these species control measures were wholly inadequate to suit farmers. I often shot wild boar from horseback and from motor car, less often nilgai which I liked to stalk. It was not a difficult animal to bag if you knew where to place the first shot, the neck or shoulder but gave considerable trouble once wounded. A buffy-white Nilgai bull was shot by the Thakore saheb of Palitana.

Of Blackbuck, Bhavnagar and Nawanagar had the largest herds. Junagadh had large herds near Veraval. In fact, this antelope was found in most States. During the rule of Jam Ranjitsinhji, Blackbuck and Chinkara were abundant. In the Nawanagar, Baradi sector, and in the Baroda Okhamandal, large concentrations of Blackbuck were seen. Small enclaves such as Atkot near Jasdan, one saw small herds of antelope because of Ranji's strict game preservation. The Bhal area, part of it Bhavnagar state, had huge herds of blackbuck and one could see them in thousands. This part had the richest grassland in kathiawar where great Indian bustards and florican bred regularly. There were many such but smaller areas in kathiawar. The largest blackbuck head of 29″ length was shot in Morvi, whereas, quite a number of 27 and 28 inchers have been measured from Bhavnagar and Datha areas. These horn lengths are good as any in India.

When we were guests of the Nawab Mohabatkhanji of Junagadh, the Dewan took us by special train to Veraval. During the journey the instructions to the Guard was to stop the train when herds of blackbuck were seen close to the line so that my brother could fire from the Royal saloon. This shows how undisturbed the antelope were. I saw much of antelope and gazelle in the states of Junagadh, Nawanagar, Bhavnagar, Virpur, Jasdan, Dhrol, Lakhtar, Limbdi, Wankaner, Morvi and even in Mangrol. Very few were seen in Gondal state whose wise ruler (Maharaja Bhagwatsinhji) did not tolerate any damage to crops by game animals and owing to the state's rich cotton soil the farmers prospered, and were not hampered by damage of crops by game species. British territory contained game but in less quantity as roving officers shot game regularly and had no shikar staff. Mangrol-on-the Sea had a fine coastal forest of *Euphorbia* in which small game and panther were found and in the forties even lions strayed into it. So large were the *Euphorbia* clumps that 'machans' could be built in the centre, from which I have watched panthers at the kill. This jungle was known as the 'Qada', some of it, extended into the golf links in which Chinkara bedded, and spoilt some of the '*Browns*'. The Sheikh of Mangrol, Abdul Khaliq, was a keen wild life preserver, and he even introduced the Red Spur Fowl in the 'Qada'. The birds did quite well there. He was also a keen falconer and I often took our team of hawks to compete with his: The climate on the Bhader river is peculiar in having morning mists on warm winter days, but soon after, the weather becomes quite cool and we found our hawks in better fettle during these days.

In the thirties, Marsh Crocodiles *Crocodylus palustris* were to be seen in most tanks and rivers of kathiawar in which they regularly bred. All tanks contained many kinds of fish and species such as Mahseer, Murrel, Mullet and carps were also seen in rivers and streams and afforded good fishing. In the estuaries the Sea Perch (*Lates calcarifer*) and *Rawas* or Indian Salmon gave anglers good sport. At Jasdan, I first came across the Glass Fish (*Ambassis*) which the Durbarsaheb Ala khacher had kept in his aquarium for me. On the seacoast, marine Turtles, mostly Ridleys were a common sight, although some eggs were taken by fisher folk and many often dug up and devoured by jackals. Watching Turtles come out from the sea to lay eggs was great fun on moonlit nights at high tide. The months of May to July were the best. On the kathiawar seaboard, many beaches were protected as temple areas and no fishing or exploiting of marine resources was allowed. These were the sanctuaries where I saw most marine animal life and sea birds. On certain coasts, Hyaenas lived in caves which were full of bats. I have seen myriads of bats emerging from caves and holes on the south-east coast of Kathiawar. Hyaenas also lived in stone quarries in company of porcupines and it was amusing to watch these animals in full moonlight.

The entire belt of the Little Rann of Kutch from Kharaghoda on the east to Morvi-Maliya on the west had thousands of Indian Wild Asses. These hardy animals could stand drought living in the hottest and driest parts of Kathiawar. They were safe from predators although occasionally a stray leopard or some wolves would take a few solitary animals. None shot them as big game, although the flesh is known to be excellent. Chasing of these animals from cars was a common practice and became a regular practice later for those taking photographs. On the rann border and in the *Capparis* studded grasslands in Dhrangadhra, as well as in cotton fields, the great Indian bustard could be easily seen and near Halvad, the Brahmins afforded much protection to Blackbuck, Chinkara and Nilgai. Similarly, typical Antelope habitats contained bustards in Okhamandal, the Panchal in the central Kathiawar plateau where the last of the Indian Cheetahs were killed, and in practically all low grassland hills. The game position was so bountiful that one could come across any of the big game anywhere in Kathiawar except the Asiatic Lion, and Deer.

While out small game shooting with R. K. Chandrabhanusinhji in the grass hills of Wankaner we suddenly came upon a panther, a lucky one that escaped as we had no rifle at the time. The Wankaner hills were noted for their grasslands where lesser florican, partridges, peafowl, and rain quails were seen in abundance not to mention chinkara, nilgai, and panther. The similar Rajkot terrain was also good but game was much persecuted there. I have seen great Indian bustard from the train near Wadhwan, and on the way to Jasdan and Dwarka. I found that the noise of the train did not disturb the birds if they were 100 yards or more from the railway line. In fact the bustard was found in small numbers everywhere except in the steep hill forest ranges. Trapping and snaring of small game was under control except for the ubiquitous Hare which still is persecuted by one and all meat-eating people of Kathiawar. Princes were not really interested in shooting the great Indian bustard but did so sometimes. Although muzzle-loaders were quite common amongst rural people, most of these arms were used to scare animals and birds off crop fields but poachers did misuse them occasionally. A landlord would also shoot Antelope, Gazelle and small game on his land, more for the taste of it than for sport.

The farming during the monsoon consisted chiefly of cereals, such as Millet and Milo often mixed with leguminous plants, and linseed, chilli, onions, lucerne, sugar cane and cotton. Ground nut farming was increasing rapidly. During the forties, the Bhavnagar ruler who had an establishment for hunting with hawks and falcons and African Cheetahs as a hereditary sport found the feeding of hawks a problem, and therefore got Punjab experts to catch and train Common grey Quails as 'callers' so as to attract the migratory birds to alight on certain fields where they were netted. These quails were captured to feed the hawks. Later, as the quails were so good eating, they were captured in greater quantity and fattened during the season. In the trapping operations, Harriers were a great nuisance as these hawks followed the quail migration and were caught in the nets often breaking them. They also disturbed the quails before netting, but since much of the netting took place before dawn, the harriers did not always intervene. During this period October to early December, I came across Hen Harriers which are seldom seen now. In the netting, partridges and florican also got caught but were released. Netting of house crows and house pigeons was done to supply meat to the Falconry Units. This was a period when Raptors were seen in abundance, and one would often see waves of Harriers, Kestrels, Eagles, Laggar falcons and quite a number of Peregrine falcons on the seacoast from October to December. Sakers were also regularly seen in the more arid areas. The White-Eyed Buzzard was the most abundant bird of prey seen sitting on telegraph poles and one could count it by the dozen in any train or motor journey in Kathiawar. The Redheaded Merlin though uncommon was seen in every countryside. Kestrels arrived by the hundred but the Black-winged Kite was not seen so frequently as the other raptors nor the Shahin Falcons. The Tawny and Bonelli's Eagles bred often close to towns, the latter even on old Palaces, but it preferred the more hilly areas, where game was more plentiful.

At Rozy near Jamnagar Port, the Maharaja Ranjitsinhji had created a small game preserve in which large number of grey and painted partridges had been introduced for organized Game Shoots. Later chital were introduced and are protected till this day by the present Jam Saheb. As artificial breeding of game birds was not done in India, huge number of netted birds were released in this small preserve with hares. In the early thirties, I remember attending the grand Rozy shoot when crates of game birds had been emptied previous to the coming Silver Jubilee of the Maharaja Jam Saheb on 2nd April 1932. The chances of running out of cartridges was the risk one took, as it was the case in some of the big duck shoots although many princes supplied cartridges to guests who often fired away at birds out of range or peppered the beaters with lead to the embarassment of the host. At the grand Rozy shoot the great Ranji happened to be walking without his gun next to me, and applauding a good shot to encourage me as I was the youngest sportsmen in the party. What amazed me was that, in this seaside preserve, the bag consisted of Chukor and Black Partridges which are not found in Kathiawar. Ranji used to have a lorry full of grain which went round the roads for feeding the game and I witnessed a sight which I had never seen before, for when this truck went round it honked and partridges and hares would run to the road to be fed as a spray of grains fell on the road like drops of water from a road watering truck. He also had men with guns shooting vermin day and night. The abundance of blackbuck and chinkara and small game in Nawanagar State was incredible. In any direction from Jamnagar except towards the sea, one could see any number of these Antilopinae. Those were the days when one got trigger-happy shooting small and big game alike.

I shot my first Leopard at Kileshwar in the Jamnagar Barda Hills sitting next to Ranji and his nephews. A trained dog seemed to be following the panther closely almost at its heels which seemed extraordinarily unusual. This dog was an expert in flushing the panther from his lair and was the key agent in most of these shikar hunts. (It reminded me of the pied pariah dog of Ranbag (Mahuva) which chased and halted wild boar by fixing its teeth on the scrotum after they had been missed by shooters from Machans so that they could be despatched by the axe later.) No sooner had I shot the panther, the dog retreated and a beater ran in with an axe to give the spotted cat its final blow. It was an amazingly well organized show and Ranji himself a very keen Panther hunter knew much about the habits of the species and how to beat it. The panther, was found in most of the forest and scrub areas of kathiawar although it had been over shot during the early century but was now rapidly coming back. The Panther was a game which was seldom shot except by Princes and their guests. The Gir forest had some very large specimens reaching eight feet. (between pegs). The panther population in the Gir was evidently larger than that of the lion. And many panthers were shot during the late thirties in all parts of Kathiawar. Some were even killed in desert and fields by villagers, as the species had multiplied in its habitat beyond carrying capacity.

In the Gir forest, lions were judiciously protected by the Nawab of Junagadh with the result that the population soon began to increase when British Dewans, Sir Patrick Cadell and G. E. Monteath were administrators. The Nawab never was keen on lion shoots but there was a constant demand from Princes and guests to shoot lions. Most of these requests were turned down. In 1929 special permission was granted to Mr. Arthur Vernay, a vice-patron of the *BNHS,* to collect a pair for the American Museum of Natural History, New York. As the population of lions was increasing rapidly, Princes and Viceroys of India were invited for shoots. And the walls of the Hunting Lodge or Camp at Sasangir were fully studded with photographs of VIPs standing over dead lions with a retinue of aides, and shikaries. My brother was invited to shoot a lion but when the photographer was called to take a photograph of the lion and the group, he ordered that all rifles should be taken away for the photograph as the lion shot from the machan was not an act of bravery and an easy animal to bag but he appreciated the invitation of the Nawab Saheb to shoot a lion. This was partly in token of a loyal officer of the Bhavnagar State Lancers Colonel Sardarsingh who had been loaned to the Nawab and had rendered faithful service to the Nawab and to whom was conferred the title of *Tazmi-Sardar.* During those years, the Nawab's hospitality was lavish and he considered our family as brothers allowing us to meet the Begum and Rani sahebs who were under strict purdah.

When the Junagadh Gir lions had increased beyond their carrying capacity and wandered into neighbouring states, the adjoining states took advantage and shot lions almost indiscriminately. This was most humiliating to the Junagadh ruler but nothing could be done as the 'nomad' lions killed cattle outside his territory and the Nawab Saheb was not ready to pay compensation owing to state rights and lack of proper evidence. Many of the states in Kathiawar were paying tribute to the Nawab in cash, as a settlement of olden times, through British guarantee. A very interesting event happened when I was in Junagadh Gir. Two well-known Princes were invited in the early forties to shoot a lion each at the same time. After the senior ruler had shot his lion, he insisted on watching the lion shoot of his brother prince from another machan. When he saw that the lion beaten out was larger than what he had shot, he promptly intervened by firing at him, killing him dead, before he reached the machan of his younger friend. This created dissatisfaction, to say the least and the younger prince then asked the Nawab to allow him to shoot two lions which permission was given after the elder prince had left.

The game position in the gir was excellent. Wild Boar specially, were seen in huge sounders and were swarming in the forest but chital were mostly found in fair numbers in the Jamwala forest division of the gir. The Sambar and Nilgai being common. I have seen Four-horned antelopes in groups of 4 and 5. And as cars were seldom allowed on forest roads all game animals allowed close approach, standing motionless or crossing the roadside to see what a car looked like. The wild boar developed huge tusks living alongside with lions and panthers and showed defiance when approached on foot. Nilgai were found in all thorn forests of Kathiawar and were the least molested creating havoc to crops as did the wild boar. A defiant Blue Bull was killed by a Railway engine near port Albert Victor (B.S.).

In the thirties, I know of no game species which may have been considered as endangered. The lion was the only rare species threatened with extinction in Asia, or rather India but this carnivore was increasing rapidly. A lion reserve at Mytiala (Bhavnagar State) had been created to extend the range of the lion and in which later discreet shooting of lions was done. The great Indian bustard which doubtless was restricted to certain habitats and localities was not persecuted, and could be considered uncommon and yet where it occurred it could always be seen easily even at close quarters. Since the species does not breed rapidly laying one egg and maturity taking some years, the increase is very slow. The Grey Hornbill of the gir forest was killed surreptitiously for its medicinal value and there is no doubt that it was rare in the gir forest at the time. The population of sambar and wild boar was nearing saturation point in the Girnar hills and increasing rapidly in gir hills and since serious working of forest had not begun, the vegetation in both areas was dense and conducive to the safety of game species: A sort of wilderness area full of malaria and small pox. In all areas of Kathiawar religious sites, be they Hindu or Moslem, afforded special protection to wildlife including marine life, and freshwater animals. Such areas were conspicuous for holding game species and respected as sanctuaries by the princes and people alike. The Gir forest, a sanctum sanctorum, yet had more game close to the temples of Kunkeshwari, Banej, Kamleshwar, and Tulsishyam. Hundreds of temple sites strewn all over the province preserved wildlife, including crocodiles. Thus these religious enclaves served as wildlife sanctuaries and were a great asset. At Sandhida Mahadeo near Sanosra, some 34 miles from Bhavnagar, blackbuck were tame enough to drink from the temple '*kund*' (waterhole) and the bucks were seen to sleep on their sides and turn over on their back in front of the temple. Dr. S. Dillon Ripley II, the famous American Ornithologist, was amazed to see such a sight when he was my guest in the forties. At this time a project to ring Lesser Florican in Bhavnagar State was launched to study migration. Near Mithi Vidi, a freshwater pool on the seashore off Trapaj contained a huge Marsh crocodile which was worshipped by the local villagers as a Goddess, (Matajee) and people bathed in the pool unmolested, a sight I can never forget. The Vala Rajputs near Mahuva, considered blackbuck sacred on their lands, and the antelope enjoyed complete safety until one police officer abrogated it for supplying meat to sailors. Similarly the Muli Prince did not kill the grey partridge in his state since one of his ancestors had given refuge to a wounded bird in his battle tent. The Peafowl was always venerated by the Hindus and enjoyed full protection by the people as did the immense population of the blue rock pigeon. Both these species therefore became overabundant causing considerable nuisance to farmers. House pigeons were frequently preyed upon by house cats and by practically all birds of prey. Yet the numbers never seemed to have diminished. Shooting of pigeons was not permitted and people did not shoot doves as a sport. Both species were very common, and still are. The panther took advantage of the abundance of peafowl in forest areas and also the jungle cats. The Langur Monkey found in the Gir and Girnar forests was fully controlled by panthers and was uncommon.

Soon after World War II broke out, the position of wildlife did not take such a drastic change as in some other parts of India where Military were given 'carte blanche' to shoot wild game, since most of the Kathiawar peninsula was under Princely rule. During the war period, wildlife in general was still increasing and as there was strict rationing of petrol, people had less time to drive about after game. Princely shoots nevertheless continued and much entertainment to the services personnel was extended. Most of the big game shooting was directed on antelope and gazelle and wild boar, and the big cats. The grow-more-food campaign, restricted the widespread growing of ground nut as a cash crop, millets were encouraged and thus during the autumn, large number of Eastern Common Crane were seen on the coastal areas, whereas Demoiselle crane which feeds largely on left over ground nut and grass seeds was seen in central Kathiawar in good numbers. The former crane arrived earlier in east Kathiawar but the latter were the first to arrive in the Bhal sometimes as early as August. During the war period, lions and panthers had increased with an abundance of natural prey. Near the cultivated tracts, the panther fed much upon domestic animals but as peafowl, hare, chinkara and wild boar were common, this feline did prey on them: The village pariah dog was always a choice food for the panther though it usually preferred goat meat. Wolves were not really rare but seldom encountered.

What was interesting to note during the thirties and forties was that farming had not reached high intensity and chasing of wounded antelope and chasing wild boar in the open fields was possible with motor cars. At Mahuva, for instance we captured a white Indian antelope, a mutant which breeds true, by tiring the animal down in stages by chasing over rough flat country, an impossibility now under present farming and soil conservation methods. A small herd of white blackbuck had already been formed in captivity and was doing very well at Bhavnagar. In Victoria Park, Bhavnagar, chital were reintroduced and now had large herds, and a variety of game species, such as wild boar, chinkara, blackbuck, nilgai, and the introduced, Hog Deer and red spurfowl which were seen breeding. Small game was plentiful. At Jamnagar, Rozy Preserve, Chital were doing very well and the African Guinea fowl also in the Nawanagar Barda hills. The entire Barda hills, contained some Sambar, Chital, Wildboar, Nilgai, and Leopard which had shown increase. I have seen half dozen panthers in one evening drive there. Crocodiles were found in the tanks and in Okhamandal also. Drought was always a problem in Kathiawar, and therefore, irrigation tanks and wells were being made in increasing numbers. By the end of the forties, innumerable tanks with irrigation canals were seen with the result that there was a greater distribution of water and consequently an increase in waterfowl throughout the peninsula.

A drastic change in wildlife conditions was seen at the dawn of Independence when severe famine threatened the people and gave way for indiscriminate killing of wildlife, mostly the abundant game species. Any holder of arms could kill game and the shikar administration of the Princes came to a sudden halt although certain exclusive rights of shooting were given to the Princes. The Bhavnagar ruler in particular did not much care for these rights as the rights of protecting wildlife and its habitat had been taken over by the Saurashtra State forest department. With the end of Princely rule one saw the tragic commencement of the destruction of big and small game species. Moreover, the establishment of the Military station at Dhrangadhra was a great blow to wildlife, as army personnel hunted game freely and the great Indian bustard was much endangered.

In Saurashtra, the Chief Minister ordered game animals to be shot at sight in fields. Restrictions on arms was relaxed and the so-called criminal nomadic tribes killed game indiscriminately. Some of these tribes were rehabilitated in central Kathiawar plateau where game had been strictly preserved with the result that it was soon depleted. Notwithstanding, it was after Independence that important dams on the rivers, Shetrunji, Bhader, Machoo, Sasoi and some smaller rivers were constructed and this enabled a more perennial source of water for industrial towns, and irrigated a considerable command area of agricultural land through canals. Cement and tar roads for bus services were made and villages were well connected by this service. Saurashtra as the State Union was known became a land of lakes and roads. It already had a network of Railways. This improvement in wet land, enabled a large number of water birds to breed and the fish supply attracted an enormous number of fish-eating birds, from pelicans to the smallest terns and kingfishers. Marsh areas increased and water fowl of many species bred. The Spotbill duck and Comb ducks were increasingly seen and frequent sightings of Cotton Teal were recorded. In contrast denudation of forest had begun under scientific working plans specially in the Gir and Girnar forests whereas the Barda and Shetrunjaya hill ranges were being cut heavily with the result that forest cover and its wildlife was being reduced rapidly. Babul and Bamboo and clear felling of teak and mixed deciduous trees caused forests to be opened out on a large scale. Thus the 1950-60 period was the most critical for forest and wildlife. And yet until 1955 the lion population had been increasing. In 1950, the first lion census was conducted under the guidance of Mr. Wynter Blyth a very competent naturalist. The trend of lion increase was noted until the second census in 1955, at which time lion poisoning had just commenced. When the Lion Show, for tourists commenced during Bilingual Bombay state, lion poisoning by Gir maldharies increased and the lion population was on the decrease. The lion census of 1963 was suspect for the lion population had by then somewhat crashed. Earlier widespread poaching in the Gir forest was seen and dacoits had made their home in the forests with the result that Police were swarming over the forests, often poaching game. This decade (1950-60) was perhaps the worst for wildlife of Kathiawar. Between the two lions censuses in the fifties, the game position in the Gir forest had slowly deteriorated and the Grey Hornbill seemed to have become extinct. The redeeming factor was creation of the new wildlife legislation based on the Bombay Wild Animals & Birds Protection Act, 1951 under which a State Wildlife Advisory Board was formed. The Gir forest was not declared a sanctuary but for a small scrub forest known as the Deolia Sanctuary. Lions were shot by special invitees of the Rajpramukh of Saurashtra with a quota of two per year. Some very fine maned lions were bagged each year. On one occasion the increased annual quota of four lions was exceeded and six lions, all good males were shot by various Princes. The shooting of a few lions had no significance to the growing lion population although the best breeding specimens were those that were killed. From 1959 onwards no permission was given to shoot lions and this continued when the Gujarat state was formed. Everywhere wild boar and ungulates were slowly being reduced by poachers including some ex-princes and landlords and also government officers. Any one who possessed a licensed arm and ate meat shot game and clandestine game markets were opened in some small towns. Despite this sad situation, there still existed big game, small herds of blackbuck, chinkara, nilgai scattered all over Saurashtra but the wild boar was much reduced. And the widespread *Opuntia* Cacti which gave it protection had been wiped out almost completely in Kathiawar. Thus a sizable cover for wild boar and small game was lost. Leopards, however, were fairly frequent in the hill ranges. During these years, intensive farming had begun. Ground nut was being planted on a larger scale and many vegetables such as onions and chillies were grown extensively everywhere, with the result that milo and millets were grown in smaller quantity. Rice was grown during good monsoons and sugar cane was spreading with the irrigated Tank and Well systems.

In the sixties, a drastic change in Kathiawar wildlife was to be seen. All big game species were reduced, specially wild boar, nilgai, blackbuck and chinkara and even panther populations outside Gir forest. The Barda and Shetrunjaya hills were much denuded and game ungulates and their predators practically wiped out. Habitat destruction in fallow and marginal land had grown: The low thorn bush was being removed everywhere for making hedges for protecting irrigated farms with the result that partridge, hare and bush-quail which nested in such cover were seeking refuge in farms and had little chance to breed in their restricted natural habitats. Sandgrouse particularly were menaced by nomadic tribes who killed incubating game birds. The 'Daffers' who possessed illegal guns swept over the peninsula killing game and selling meat. No action was taken against this community and it still continues its nefarious poaching. The Green Pigeon in Eastern Kathiawar so common in Mango and Fici groves was poached and with the denudation of the Sihor hills Forest, which apart from the miscellaneous trees had a pure forest of *Acacia senegal* which produces gum of medicinal value and the finest white honey in Kathiawar, (A similar forest existed in Wankaner state) the birds were easily shot. The Green Pigeons of the Gir were being poached for the same medicinal purpose as the grey hornbill but since the "*Harial*" pigeon population was so large it had little effect. More serious was the cutting down of trees which opened the forest considerably. Undergrowth in which small and big game took refuge was removed by forest contractors and poaching of game was rampant. The Girnar was overcut as were the outer hills with the result that Sambar were easily poached. Large scale illicit cutting of forest in Gir compelled the Forest department to mobilise a special squad to deal with this menace. During drought years, large number of domestic animals from other parts of Gujarat entered the Gir forest causing serious disturbance to its ecosystem. The Maldharies also were moved to lop and cut trees to feed their animals. By the end of the sixties the wildlife position in Kathiawar was grave. Grocodiles had been reduced drastically and endangered. With intensive farming came the widespread use of pesticides and insecticides and birds of prey commenced to be affected seriously. Although lion poisoning had been controlled, animal life which ingested poisoned or partly poisoned food was eventually being reduced. Migratory birds of prey, Harriers, kestrels, and eagles and falcons were not seen in the same number during migration. Resident raptors doubtless were much diminished and I saw some being electrocuted by alighting on high voltage pylons. Ground nesting birds were menaced either by roaming cattle or by pilferers of eggs. Predators were able to find nests much more easily owing to lack of natural nesting cover. Civet cats succumbed to poisoned food as did many raptors such as the common White-Eyed Buzzard, Tawny Eagle, and Laggar falcons. Denudation of typical grassland-scrub in hill areas also affected the Short-toed and Bonelli's Eagles.

The situation in the seventies for wild life seemed dismal with the paucity of birds of prey, and birds in general were not seen in the hordes as in the past. The Monitor lizard and snakes so commonly seen everywhere now were less seen except in the semi desert and arid areas. There was, no doubt, a growing change in the increase of waterfowl, for, during good rainfall, most wet lands had enough water and cover for birds to breed. The increase in sighting of Cotton Teal and Ducks such as Spotbills and Nuktas was a sign of progress. Spoonbills, and a variety of herons bred in urban areas and the little brown crake had much extended its range in the widespread marsh habitat. The Sasan-Gir Forest Ecological Study team consisting of young foreign biologists studied conservation and grazing problems of the Gir forest in interest of serving the Asiatic Lion. A Gir Sanctuary Project had been started and measures to demarcate the lion habitat and give fuller protection to it was launched. A rubble wall with live hedges was constructed on the vital periphery of the forest at a high cost so as to prevent indiscriminate grazing in the Gir Lion Sanctuary; later a National Park area was established where no cutting or grazing of cattle was permitted and a scheme to rehabilitate the innumerable 'Maldhari' hamlets outside the main Gir forest was underway. Unfortunately, drought years intervened, and the rehabilitation program had to go slow. Wildlife Department in the form of a Wildlife Wing within the Forest Department was created and this set-up, helped the forest ungulates to recoup in the Gir forest. So satisfying was the progress that in 1974-75, the Gir National Park-cum-Sanctuary was awarded the Trophy for the best managed wildlife reserve in India. The Lion Censuses of 1968 had shown a decrease in the lion population but in 1974 it had reached to 180 lions. Owing to Revenue forest on the Gir periphery having been thinned or plowed for agriculture the lion habitat had further shrunk. And yet Chital population had shown an increase and the wild boar population which had crashed was soon coming back. Blackbuck had been seriously depleted throughout Kathiawar and yet, in the Velavadar Sanctuary for Blackbuck, the herds had grown until in 1975 a cyclone destroyed nearly a thousand. A Census taken in 1976 gave a total of 1676 animals. A National Park for the Indian Antelope was established and a Lodge for visitors is being built. The adjoining Mithapur grassland is now under the plow and has reduced Blackbuck habitat. Moreover, the invasion of *Prosopis juliflora* endangers the grassland so vital to the blackbuck. *Prosopis juliflora* in Kathiawar is now conspicuous everywhere. With it, the stone curlew and small game is seen in fair number. The population of chinkara was so depleted that it has become a rare animal and this also applies to wild boar and even nilgai.

The Nal Sarowar, the largest 'Jheel' in Kathiawar near Limbdi turns saline towards the dry season and often goes bone dry in the hot weather. This open shallow sheet of water is a sanctuary in which water fowl are constantly disturbed by poachers who live in villages on its periphery. These people are professional netters and snarers and are difficult to control as their livelihood depends upon poaching. The dual administration between the Forest and Tourist departments is wholly inadequate and the Watch Tower for birdwatchers is designed against all principles of watching birds at the waterside despite the advice from experts. And yet, the Nal Sarowar an ideal waterfowl refuge is a popular holiday resort for the Ahmedabad city folk. The best time to see Nal sarowar is in March when water recedes and water birds of many kinds are in full plumage for their return migration. But one hardly gets a close view of the birds owing to constant human disturbance.

On the Kathiawar Seaboard, innumerable salt works now line the shore and these semi saline compartments have attracted countless waders and we now see Common Shelducks formerly so rare. Flamingos of both species, large and small, forage in the compartments with many waders, gulls and terns and one often sees Pelicans. These graceful flyers usually visit many of the larger drying tanks in early summer. In rivers and tanks, fish have been much depleted. Most tanks have small fish with the result that, the Large Cormorant, Fishing Eagles, River and Blackbellied Terns are infrequent whereas little Terns so seldom seen in the past are seen throughout Kathiawar, breeding in salt works and tanks. Crocodiles have disappeared except at Kamleshwar tank in the Gir and in a few remote water courses. Near Sasangir, a Crocodile Breeding Project has been commenced. There are a few temple areas where blackbuck and nilgai are preserved owing to religious sentiments. Small game close to towns has been much reduced by poaching and the Military Stations at Jamnagar and Dhrangadhra have caused most game to disappear in the nearby areas. The total ban on hunting has not been a solution to the widespread poaching by nomads and hunters who are bent on killing game.

Although, there is now more understanding amongst citizens that wildlife preservation and photography holds more importance than killing wildlife, the people who kill game for meat are still at large and the Forest-cum-Wildlife Department is unable to control this menace. There is no dedicated wildlife service in the state department specially with the transference of officers whose main duties are in forestry. An additional Chief Conservator of Forests for Wildlife (G.S.) is now appointed and matters stand at that. Nevertheless, more sanctuaries are being planned. The so called Sanctuary for the Indian Wild Ass in the Little Rann of Kutch is so large and its components so diverse and scattered that it is like a jig-saw-puzzle and, the boundaries are so interspersed with crop land and salt works that it makes enforcement of regulations a difficult problem. The last Wild Ass Census 1976 showed a population of about 720 animals in comparison with the thousands I have seen in the thirties and forties. No one seems to really know how the animals vanished so rapidly unless perhaps by epidemic disease. An aerial census in 1969 merely conveyed a number less than 400 animals although a small herd had migrated to the Nal Sarowar and stray animals are sometimes seen there.

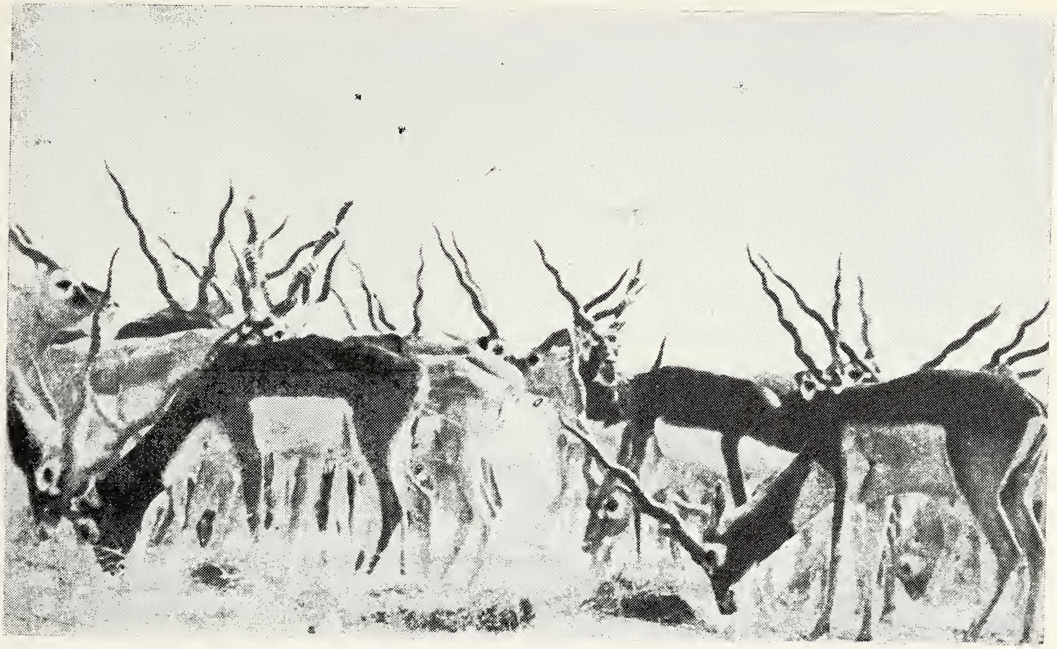
When I surveyed typical habitats of the great Indian bustard in 1970-71 for the World

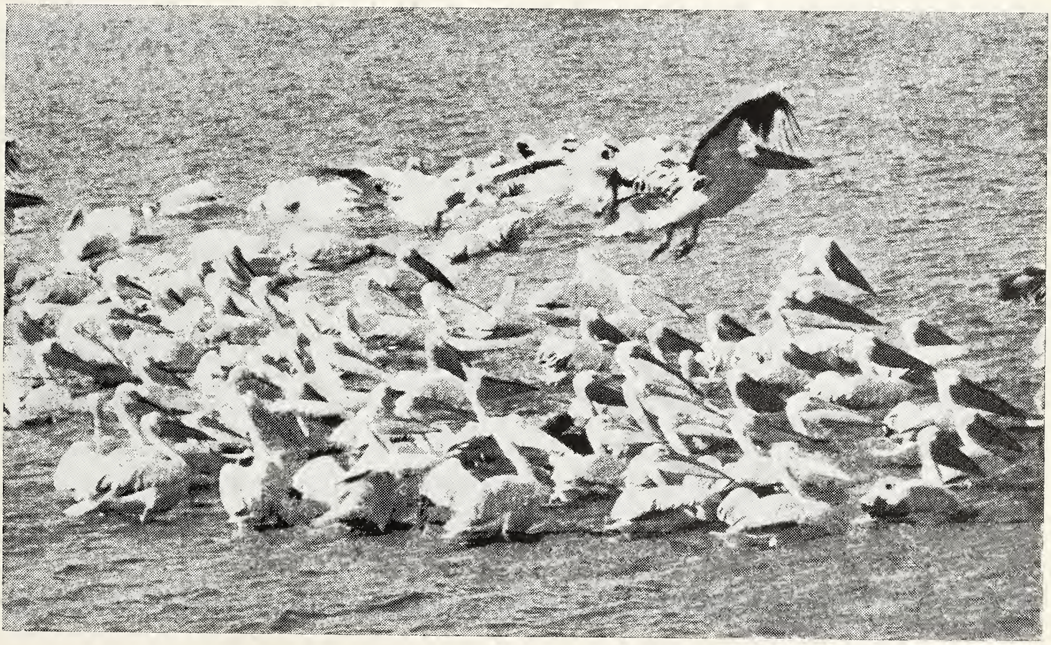
Wildlife Fund, I was struck by the paucity of antelope and gazelle in those ideal biotopes and as for the bustard it had become very rare. The last stronghold of this species in Kathiawar appears to be in the Jamnagar District close to Okhamandal, where the staunch Iyer community allows no trespassing on their lands and the birds seem to realise this protection where they are undisturbed. There is also some waste land where birds breed. Scattered birds may be seen in the Panchal plateau and on the Rann border where formerly they were not uncommon. The bird is certainly endangered in Kathiawar where nomadic communities poaching wildlife are at large.

With the establishment of a Wildlife Conservation Society at Bhavnagar, and World Wildlife Fund Nature Clubs for Young Folks, at Rajkot and other places, a new outlook on education and conservation of nature has been started. Nature camps at Hingolgadh near Jasdan have been a great success and it appears that the area will get recognition and protection by government. Much of this credit goes to Sarvashri Shivarajkumar Khacher and Lavkumar Khacher of Jasdan. But these bodies have no right to enforce the laws for the protection of wildlife. The Wildlife (Protection) Act, 1972, is exercised by the Forest Department mostly through its CCF Wildlife and Wing. Nature Clubs of the World Wildlife Fund has central office at Rajkot and this augurs well for the preservation of wildlife.

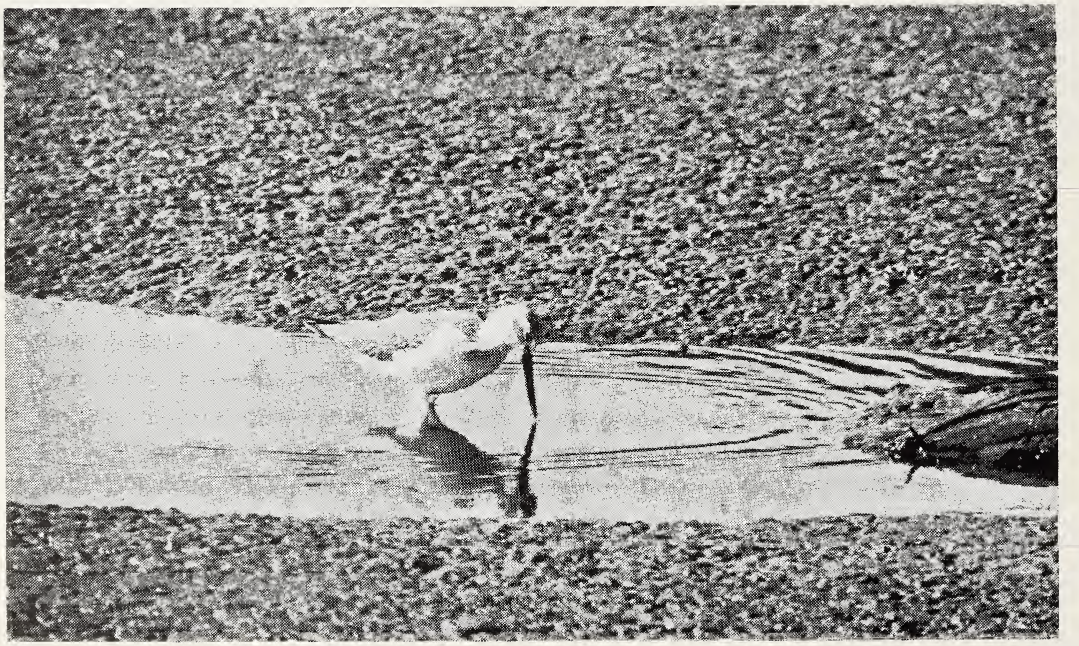
Owing to denudation of most thorn forests and poaching of rare or uncommon animals such as the Pangolin and Ratel these species have become much rarer. These two species were found in many hill areas of Kathiawar; now it appears that their main stronghold is in the Gir and Girnar forests and perhaps Barda hills. Ratel pugmarks are quite commonly observed on dusty roads of the Gir forest. The Wolf, is now uncommon and even common canidae such as the Indian Fox is much less common. It is much persecuted by tribal hunters. The species endangered consist mostly of Antelope and Gazelle, and the panther is rare except in the Gir forest. Similar is the case of the wild boar. The Blackbuck is doubtless endangered and the great Indian bustard is threatened with extinction. The common Painted Sandgrouse so common in the low grass stony hills, is seen in less number except in Gir forest. Local populations of birds such as the Green Fruit Pigeon of eastern Kathiawar is much threatened and any species can now become endangered in areas where its biotope is removed or upset. Even the common Sandgrouse is not found as abundantly in the countryside owing to intensive farming and spoiling of its low stony and marginal breeding habitats and also to direct killing by nomads.

The conspicuous change in the countryside is the intensive farming and with it the large number of tanks and irrigated farms. The spread of *Prosopis juliflora* is something to be wondered at, for large belts of this plant has created impenetrable thickets and is prolific on roadsides. This has solved a problem for supplying fuel and other purpose wood to rural people everywhere. On the coastal belt, it has been planted to stop the spread of desert and sand dunes and acts as a buffer to high winds. It seems to spread rapidly with the movement of domestic livestock. With water conditions being doubtless better than in the past, water birds and birds visiting farmlands are now fairly commonly seen and even nest. Roadside plantations are slowly coming up but the proper drought resisting species or those affording the best shade are not always planted. In the seventies, the position of wildlife is seen in a transitional stage. It is difficult to say which species of wildlife will be seriously





Above : Blackbuck in Velavadar Sanctuary (now National Park).
Below : Rosy Pelicans at Rajawadla Tank (near Jasdan). (Photos : *Author*)



Above : Crab Plovers at Ghogha spithead (Gulf of Cambay).
Below : Greenshank feeding. (Photos : *Author*)

affected owing to widespread spraying of insecticides and pesticides, repercussions of which, have already reduced birds-of-prey, but birds like the Blackwinged Kite which tend to prey upon life which moves in a healthy manner are those which have not been seriously affected; the Blackwinged Kite for instance has increased specially with rodent increase, but on the whole raptors have shown decline and species such as the Short-toed, Bonelli's and Tawny, Eagles have definitely diminished to low numbers also the White-Eyed Buzzard. General denudation of forests in the entire Kathiawar peninsula except for vegetation in farms and the *juliflora* has caused much of wildlife to be reduced. The large stands of Babul thorn and scrub forest have almost disappeared. The many babul trees which during the monsoon stood in 'jheels' affording nesting cover to waterbirds are now scarcely seen. There is a growing need to create habitats for tree nesting waterfowl. The most drastic impact on wildlife is from the conversion of grasslands into agricultural land. But for certain grasslands covering hills, the plains grasslands have almost totally been destroyed. And now there is no room for the resuscitation of those rich grasslands in which bustards, francolins, quails, and larks bred and sought refuge. The only large sizeable wildlife ecosystems that have survived are those of the Gir and Girnar forests and to some extent the Barda hills. There is a move to save part of the Barda hills by creating a new centre for the Asiatic lion. Whereas, the much denuded Shetrunjaya Hill, near Palitana needs reafforestation as do many of the low thorn forest ranges such as Alecha, Khokhra, Salemar and Lonch hills. The population of goatherds and cattle owners have increased so much that it is a real threat to forest vegetation. Tourism in Gir forest to see lions has become popular and there is every possibility of creating more tourism by improved management. The Gir forest is now intersected by roads leading to temples and traffic has increased. Although this does disturb wildlife on the roadside, it is not harmful unless poaching is done from roadside, otherwise the roads afford excellent view of wild animals and forest. The growing population of the Langur monkey in Gir forest needs careful watching. With human increase and artificial feeding these monkeys can be a menace to forest and cropland.

With proper fish introduction and turtle and crocodile breeding projects under scientific supervision the position of these threatened species could improve. Control over insecticides and pesticides using only those that are not harmful to wildlife should save our wildlife from complete destruction. Then only will it be possible to avert the drastic decline in wildlife of Kathiawar but under present day conditions it seems difficult to meet the crisis, as many, if not most, food crops are dependent upon spraying of pest killers. The migration of cranes to their wintering grounds in kathiawar depends much upon the food availability during their stay. Ground nut provides the main source of food and most of it is dug out by the cranes specially those which have remained unpicked. These nuts are now being collected by poor people with the result that the cranes find their food wanting and find it difficult to sustain themselves. And yet large number of Demoiselle cranes arrive in autumn. They then do much trampling in cropland without obtaining their food. Whereas, the resident Sarus crane which feeds in water as well as on land and is protected by sentiment by the people is able to survive and increase.

To summarise the changes I have seen in the last five decades is as follows: (1) Habitat destruction of *Acacia* and grassland and fici trees and the removal of *Zizyphus* and undergrowth for making hedges. (2) Drastic decline of big game species with fluctuation in lion population. The species most affected are; Blackbuck, Indian Wild Ass, Chinkara, Wild Boar, Sambar, Nilgai and Panther. In small game; Bustards, Quails, Fruit Pigeon and even Sandgrouse and Painted Partridge; Hare and all ground nesting grassland birds also. The reduction in number of most reptiles is conspicuous. In small mammals; the Desert Cat, Fox, Pangolin and Ratel are threatened. The Wolf is holding its own in hills and marginal land but is much less seen being considered vermin by the shepherds and goatherds on whose livestock it mainly preys.

Among birds, the Grey Hornbill appears to be extinct as a resident bird of the Gir but can be reintroduced. Birds of prey and most insectivorous birds are less seen. However, Cattle Egrets and the Herons and Storks seem to be less affected, the latter two kinds feed much upon unpolluted aquatic life, in the seacoast and tanks and swamps. In insects, the Honey Bee is seen less. Plant life except *juliflora* in marginal and forest areas has diminished and it is difficult to say where and what species has suffered most. The Gir Orchid is threatened and many of the plant species of the Barda and Shetrunjaya hills are depleted. Most Eucalyptus plantations have failed. Although much afforestation work is carried out no substantial new forests have grown barring that of *Prosopis juliflora*. This is mainly because indigenous drought-resisting species are not planted, nevertheless, roadside trees have begun to grow. The increase in human population in rural areas with its concomitant intensified agriculture and domestic livestock has been an indirect threat to ground nesting birds. The animals often trample eggs or young and with the receding of water levels in tanks, the animals, etc. reach islets for grazing and destroy eggs and young. The increase in Crow population also has had adverse effect on bird life. In Urban areas crows have increased and they enter forest or scrub areas and feed on eggs and young of most bird species specially during the breeding season.

The progressive change in Kathiawar has been the increase in tanks, and irrigated farmland. As marsh and water habitats have spread more water birds and waterfowl are seen breeding in good rainfall years. Monsoon nesting birds such as Weaver birds and ducks and water-hens, including moorhens, crakes and painted snipe are now more common. Farmland attracts many birds specially cattle egrets lapwings and migratory birds and parrakeets have shown marked increase. The spread of *Prosopis juliflora* throughout the peninsula is amazing and one may see green belts of this plant everywhere. Because of innumerable tanks we see more of Pelicans, Flamingos, Terns, Egrets, Ibises, Spoonbills, Darters, Little Cormorants, Herons and Storks but not so the Blacknecked Stork. In short more of water birds specially of the migratory kind are now seen plentifully on the shores of tanks and sea. The salt work compartments attract large number of birds such as Blacktailed Godwits, Sandpipers, Stints, Shanks, Ruff, Plovers, Gulls, Terns, Swallows, Avocets, Flamingoes, Herons, and Brahminy ducks. White Storks are regularly seen in marshy areas and Painted Storks and Spoonbills are common birds with various species of Ibises. On the Coast, Crab Plovers are now frequently seen. With the growing number of Birdwatchers, new records of birds are added to my book BIRDS OF SAURASHTRA (1955). Birds such as the Ortolon Bunting, Blackcapped Kingfisher, Whiteheaded Thrush, House Martin, Black-throated Weaver bird, and many others, have been added to the list of birds of Saurashtra. This growing interest in birding will bring to light, it is hoped, more new records and the saving of vanishing and threatened species. Bird Camps are being held in different parts of Kathiawar. The farmer is also becoming conscious to protect wildlife in his farm and is aware of those species damaging his crops. Although there is much persecution of the Honey Bee by poor communities, private gardens in urban areas have preserved beehives despite depredation of the Crested Honey Buzzard whose population is not so seriously affected by insecticides. With the increase in House Crows, Koels are seen in greater numbers but are inadequate to control the growing crow population. Although there is a general reduction of insect species the menace of malaria is again raising its head. It is not possible to say which species of insect life has increased for the benefit of man. Insect life affecting crops has been somewhat controlled. Many students all over Kathiawar are now taking interest in natural history and research. The endangered Wild Life are of Grassland and Scrub Ecosystems, and Marginal lands, whereas, mixed dry deciduous forest in Gir is slowly recovering.

All big game mammals, and predators such as the Desert Cat, Wolf, and Civet Cat need protection. The porcupine which was so abundant in the past is not tolerated now by farmers and is much less but not yet seriously endangered.

Most insectivorous and carnivorous bird species have been threatened, either by habitat reduction or insecticides and pesticides if not both. Much of the game species have been reduced by direct poaching, but small game continues to thrive in farmland. The Eastern Common Crane and migratory Quails are seen in less numbers and the Blacknecked Stork which fed on fish in shallow waters and rivers has found survival more difficult except on seacoast. Tall trees on which it nested are less. The position of the Lesser Whistling Duck is difficult to assess: Large congregations are now not seen but its water habitat has definitely increased but nesting habitat appears to have lessened with the result that its breeding has been hampered and predators and poachers have more chance of robbing its eggs. Yet, as a whole, the population might have increased. The last stronghold of the forest wild life is the Gir, Girnar and Barda hills and these ecosystems need proper conservation for the perpetuation of the valuable wildlife of Kathiawar. Fortunately, the people of Kathiawar by nature are not destroyers of wildlife but with lack of proper enforcement of Wild Life Act and rules and general lack of appreciation for the value of wild life owing to ignorance, wildlife is bound to suffer.

In conclusion I would like to say that since the Lion Shows began in 1959 the behaviour of lions have changed. Owing to the frequency of 'baiting', lions have become tame knowing very well that man provides easy food for them and young cubs when grown become so acquainted with the Shikaries and visitors that they permit very close approach on foot. Today the Gir lion is in the tourist limelight. Moreover, thousands of people, young and old have a chance to watch and photograph the rare asiatic lion. Formerly before independence lions were shy and would not come to the baited "kill" if they knew they were being watched. I have often seen lions from Machan and if by chance they discovered me they kept away. Seldom did a lion attack livestock in day time and the Maldhari could drive away a lion from his kill easily. Tourism has also brought people to see the Indian Wild Ass from all over the world but with lesser enthusiasm. When salt works entered the Little Rann, donkeys were brought in for work, resulting in Wild Ass-Donkey hybrids. With the increase of habitation, village domestic cats in arid areas interbreed with Desert Cats and one often saw a spotted hybrid which seemed to supplant the wild species.

These are then the changes I have seen during the years and I notice that the type of crops grown, the rainfall and drought and pollution not to mention party politics and population growth play an important role in the increase and decrease of wildlife populations of Kathiawar.

THE PRESENT STATUS OF MAHSEER (FISH) AND ARTIFICIAL PROPAGATION OF *TOR KHUDREE* (SYKES)

C. V. KULKARNI[1] AND S. N. OGALE[2]

(*With two plates and two text-figures*)

Mahseer has long been a great favourite of the anglers and also constitute an important fishery in north India. Six different species of Mahseer occur in India. However, the fishery has suffered a serious decline due to indiscriminate fishing of brood fish and juveniles by unjustifiable methods. Some of the handicaps in their natural multiplication are the long hatching period of 80 hours and a still longer duration of six days covering the semi-quiescent stage when the hatchlings remain clustered in corners and crevices and away from light. Heavy mortality takes place during this critical period. Hence, one of the methods to rehabilitate this group of fishes is to breed them artificially and distribute the fingerlings into natural waters. For this purpose, a system of catching the ripe brood fish from the spawning grounds, stripping them and fertilising the eggs was followed in the case of *Tor khudree* (Sykes) at Lonavla, Dist. Pune in Maharashtra. Large number of eggs were thus collected during breeding seasons (July-August) and hatched in running water. After the hatchlings pass through the quiescent stage, the fry are fed on zooplankton and then on artificial feed. They take about eight months to reach fingerling stage, suitable for stocking. A new method of transport of these eggs in moist cotton wool was tried and found successful.

INTRODUCTION

Mahseer, the noblest sport fish of India which had been a great favourite of most of the anglers, Indian as well as those hailing from distant countries the world over, is now feared to be in danger of extinction in some parts of the country. One ardent angler (M. L. Mehta) gave a vivid pen picture in the *Times of India*—(6-6-1976) of the wanton destruction of Mahseer in the rivers near Dehra Dun (U.P.) and appealed for a 'Save Mahseer' campaign.

The National Commission on Agriculture (1976), in its report on "Fisheries" stated "It has been reported that there has been a general decline in the mahseer fishery due to indiscriminate fishing of brood fish and juveniles and the adverse effects of river valley projects" and recommended "extensive survey and detailed ecological and biological investigations." These statements are significant, and necessitate remedial operations for conservation of this group of fishes which was at one time referred to as one species, the mahseer (*Barbus tor*). In the case of species from an aquatic environment, waiting for convincing proof of depletion may be dangerous as it may then be too late to retrieve. Methods of rehabilitation and conservation have therefore to be thought out in time and the same are attempted in the present article.

Although references will be made to different species of mahseer and their fishery status, the notes will deal largely with methods of artificial propagation of *Tor khudree* (Sykes) and transportation of its eggs packed in moist cotton.

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Several species of the Mahseer exist, the principal ones being (1) *Tor putitora* (Ham.), (2) *Tor tor* (Ham.), (3) *Tor mosal* (Ham.), (4) *Tor khudree* (Sykes), (5) *T. mussullah* (Sykes). They have their own areas of natural distribution, ranging from the Lesser Himalayan region (Kashmir) to Darjeeling hills in the east, for the first species; the sub-Himalayan range, Ganga and Narmada river systems for the second; the Mahanadi basin (and also Burmese waters) for the third; the entire Peninsular India south of river Tapi for the fourth and the Peninsular rivers including Krishna and Godavari for the fifth. *T. khudree* has been reported from some parts of Narbada, North Gujarat, U.P. and Orissa also. Moreover, another large-scaled fish of Nepal and the eastern Himalayan range, the Katli or Bokar of Assam (*Acrossocheilus hexagonolepis* McClld.) is also included by anglers in this group and is designated as chocolate or red mahseer. *T. progeneius* (McClld.) of Assam and two sub-species, *T. mosal mahanadicus* (David) and *T. khudree malabaricus* (Jerdon) have also been reported.

PRESENT STATUS OF THE MAHSEER

Mahseers are well known sport fishes of rivers and streams in India and though their capture on a commercial scale must have been in practice in the past, only the catches made by anglers as a result of sport fishing have been recorded by some of the angler-authors. Sport fishing has shrunk considerably in recent years resulting in lesser competition, yet the reports of anglers are disappointing both in numbers and size (personal communication). The commercial fishery of putitor mahseer in Jammu, Himachal Pradesh and Uttar Pradesh consists largely of individuals either ascending streams for breeding or the spent ones returning to perennial pools in the plains (Sehgal 1972). Though exact numerical statements are wanting for proper comparison, whatever figures and reports of anglers are available, indicate considerable decline in the fishery (Sehgal, loc. cit.), especially of large ones. In Madhya Pradesh, particularly in the Narmada river near Hoshangabad and in Tapi near Barhanpur (Karamchandani *et al.* 1967) tor mahseer figured prominently in the commercial catches about 12 years ago but the landings are reported to have dwindled remarkably in recent years. In the lakes in Rajasthan as well as in the Chambal river between the Gandhi-Sagar and Rana Pratap Sagar reservoirs, the tor mahseer does occur in good numbers but their fishery status cannot be determined in the absence of previous catch data.

In Maharashtra also, the fish (*T. khudree*) has been practically a rarity in rivers Bhima, Krishna, Koyana, etc. except at a few temple sanctuaries at Dehu and Alandi on the Indrayani river and in some reservoirs. In the south also, the situation is in no way any brighter as regards occurrence of mahseers (*T. khudree* and *T. mussullah*). Kaveri (Cauvery) river which was at one time a home of large mahseers has been reported to be practically denuded of this anglers' delight and had to be stocked with fingerlings of the Deccan Mahseer *Tor khudree* (Sykes) from Lonavla (Maharashtra). A recent report appearing in the Deccan Herald (4-4-78), however, records a catch of 12 mahseers including a 92 pounder (42 kg) from Kaveri river, 100 km from Bangalore, by a British Trans-World Angling Team, but even this fish was caught only after an intensive effort for about 2½ months by three experts.

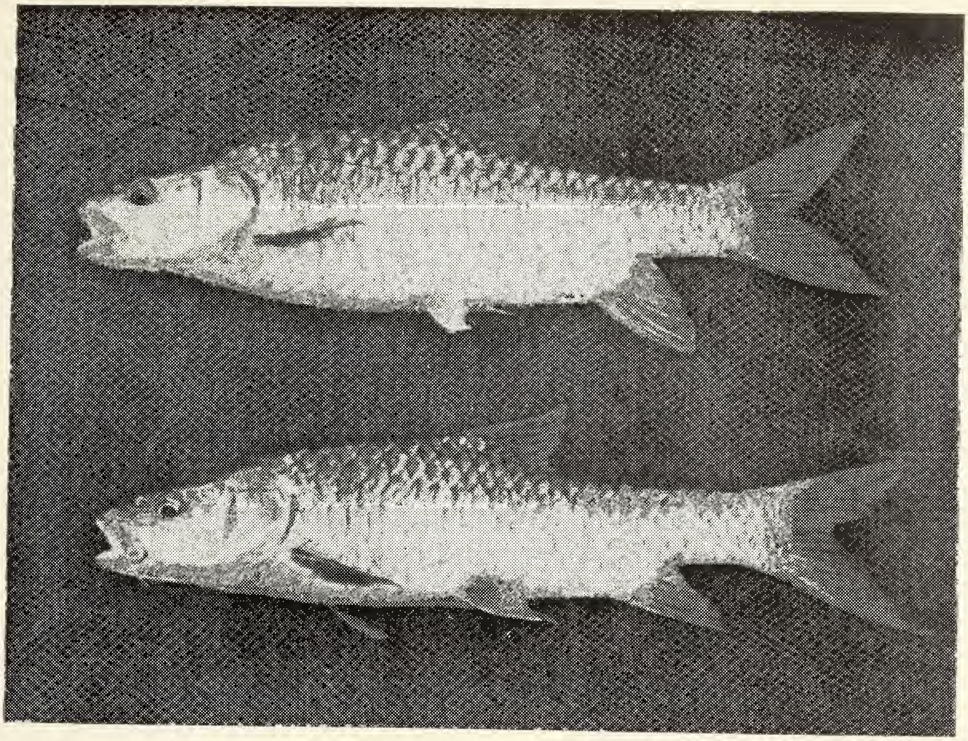
Studies on the biology and angling capabilities of these species commenced with Thomas (1897), Khan (1939), Hora (1943), McDonald (1948), Nazir Ahmed (1948) and David (1953); but more intensive work on different species started only recently with the investigations conducted by Karamchandani *et al.* (1967), Kulkarni (1971), Desai (1972 and 1973), Tripathi (1978) and Das *et al.* (1978). Despite these studies, no steps for conservation and rehabilitation of mahseer have been taken so far on a sizable scale except in the lakes of the Tata Electric Companies at Lonavla (Maharashtra) and the efforts by the Wild Life Association of South India and the Karnatak Fisheries Department in cooperation with the above company.

One of the main reasons for the decline of Mahseer, is the thoughtless destruction of this fish by illegal means such as the use of explosive and killing of brood fish in the spawning season. Another serious handicap the fish suffers from, is the change in the ecological condition of our riverine systems where several new multipurpose dams are being erected across numerous streams, large or small, all over the country. Such dams are no doubt, beneficial to the country in several ways; a number of large impoundments which would not have, otherwise, come into existence are created by these dams. This expansion of water bodies is advantageous to fish and fisheries in general but migratory fishes like Mahseer which used to visit clear water streams for breeding can no longer undertake those ascends unmolested, as human interference has penetrated into most of the previously secluded streams. It must, nevertheless, be admitted that Mahseer has, at many places, adapted itself admirably to life in the lacustrine conditions and manages to breed though on a small scale. These adverse circumstances reduce the chances of survival of Mahseer in large numbers in natural waters.

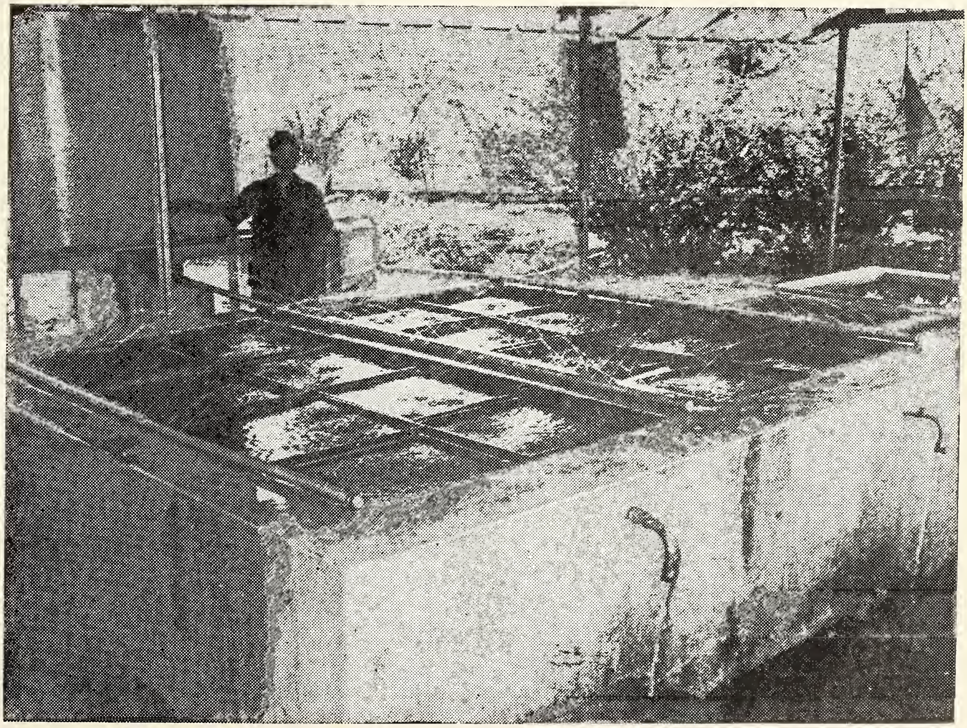
BIOLOGICAL CONSTRAINS IN NATURAL BREEDING

The Mahseer requires specialised biological conditions for its breeding and juvenile development. These were not clearly known so far. Observations on the early development and growth of hatchlings of *Tor khudree* made during past few years at Lonavla in Maharashtra (Kulkarni 1971) have focussed attention on the fact that this Mahseer (Photograph 1) suffers from several handicaps in its natural breeding. Firstly, its fecundity is comparatively low. Karamchandani *et al.* (1967) calculated fecundity of 30,420 ova for *Tor tor* of 625 mm in total length and Desai (1973) recorded 42,600 eggs for a 657 mm female of the same species; we have counted 20,000 ova from a 630 mm. *T. khudree* weighing 3.6 kg from one of the Lonavla Lakes. This is very low as compared to Catla (1,33,000 Av.) Rohu (2,61,000 Av.) per kg of body weight (Sukumaran 1969). Secondly, the hatching period is as long as 80 hours in water temperature of 22 to 26°C (Kulkarni, loc. cit.). This period is likely to be longer in colder streams of sub-himalayan region which the other species of Mahseer namely the *T. putitora* and the Katli Mahseer (*Accrossocheilus hexagonolepis*) inhabit. Further the semiquiescent stage after hatching which is hardly 3 days in other carps is extended to as long as six days in *T. khudree*. During this period the hatchlings do not swim freely but remain at the bottom mostly huddled up in large numbers in corners and crevices with their heads tucked away from light, as if they are negatively phototropic, with their tails vibrating and jutting out (Fig. 2b). In this condition they are subject to depredation in large numbers by predatory animals. Thus this semi quiescent stage is the most critical stage of their life and since it is prolonged, their mortality is also heavy. In all probability *T. putitora* and *T. tor* will have similar semi quiescent stage in their early life history, making them equally vulnerable to infantile mortality. In the past, the number of streams unfrequented by men was large and a greater number of mature mahseers had the opportunity to spawn unmolested and hence the critical quiescent stage in their life history did not matter very much. But with the increasing number of streams being used for reservoirs for multi-purpose development schemes, the traditional breeding grounds of the mahseers are lost to them. On top of this adverse situation, many of the streams which are excluded from the developmental activities, are affected by harmful industrial effluents which kill the fish fauna, and especially the tiny fry or the hatchlings in enormous numbers. All these handicaps combined together are working adversely on the fish fauna in general and on Mahseer in particular, because no effort has so far been directed towards rehabilitation or salvaging this group of fish, their specialised features in breeding and early development working against them. Hence, the only remedy to save them from this grave situation is to assist the fish in their critical stages by closely studying their breeding habits and by resorting to artificial method of propagation as is done in the case of the famous Salmon fishery in parts of north America and Europe where millions of fingerlings are raised by artificial methods and then released into natural waters. It is for this reason that methods of artificial propagation of this noble fish of India were studied and the details are given here under.

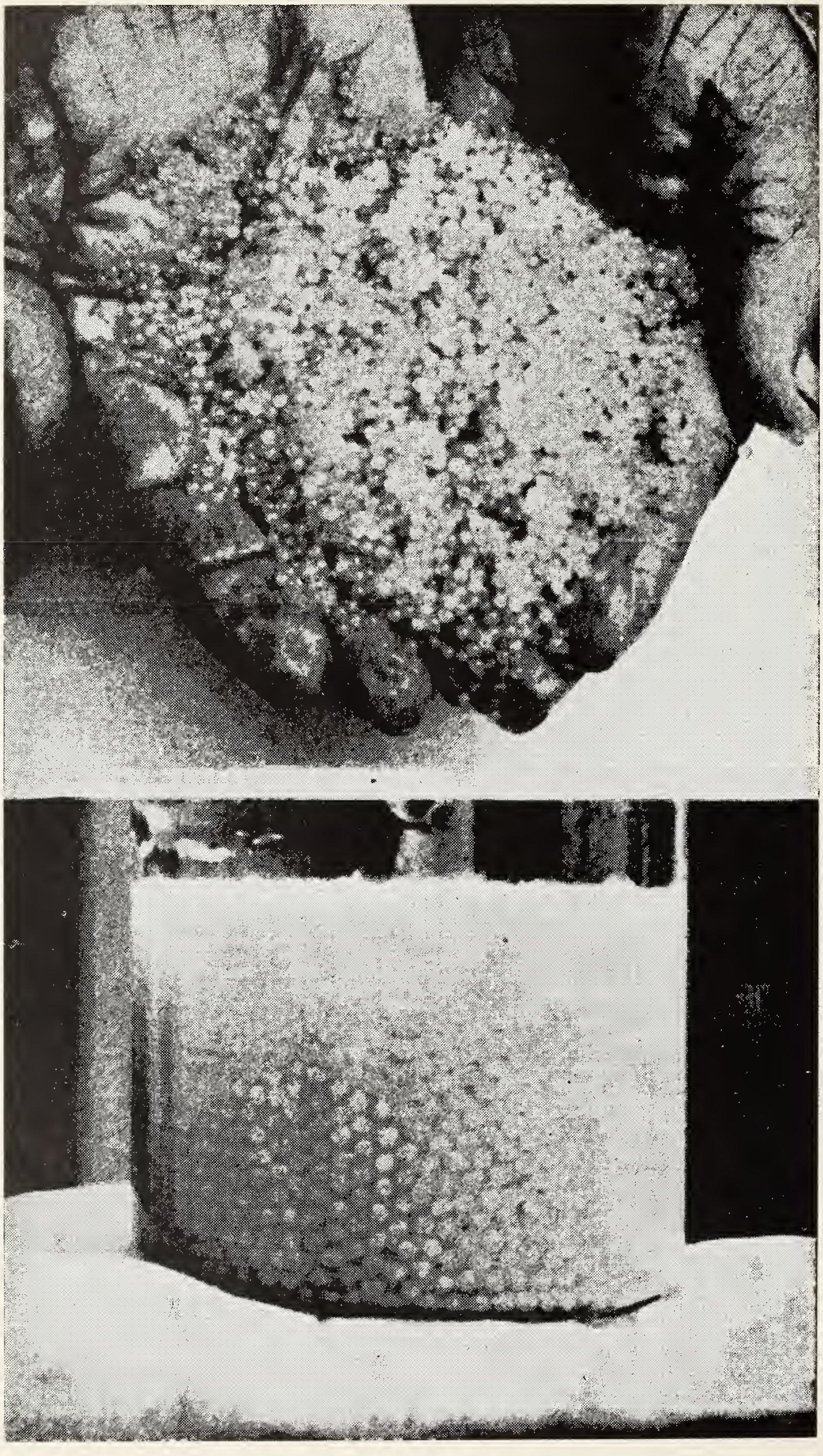
Breeding Habits: Different breeding seasons of different species of mahseers and in different climatic conditions described by several authors have been enumerated by the senior author (1971). Detailed biological study based on examination of a large number of specimens obtained from the commercial catches of mahseer from the Narbada river in Madhya Pradesh was undertaken by Karamchandani *et al.* (loc. cit.). The examination of ovarian eggs and their maximum sizes in different months enabled them to conclude that the breeding season of *Tor tor* commences in July or August and continues upto December, the peak season being from July to September. Their observations tally, to some extent, with those made at Lonavla, except that the length of the spawning season is not as long as recorded by Karamchandani *et al.* (loc. cit.). Even the peak of the season is not long enough at Lonavla, being only mid-July to mid-August, where the spawning season was determined not on the basis of maximum diameter of ova found in the specimens examined, as was done by Karamchandani *et al.*, but on actual collection of brood fish in real ripe condition, stripping of eggs and their fertilisation. In this respect, Codrinton's (1946) statement that 'major spawning period of Mahseer is in August largely agrees with the observations made at Lonavla. Record of eggs collected and fertilised at Lonavla during past eight years is as under:—



Deccan Mahseer (*Tor khudree*) Female, above; Male, below.



Hatchery Tank with water being sprayed on the hatching trays.
(*Photos*: Author)



Above : Eggs of Mahseer.
Below: Eggs of Mahseer in water. (Photos: *A. V. Shukla*)

Time	1971	1972	1973	1974	1975	1976	1977	1978
July 1st Week								
July 2nd Week			5,700	36,000	19,800	63,000		1,12,800
July 3rd Week	14,000	21,500	30,900	14,600	23,400	92,400	1,00,200	1,08,800
July 4th Week	3,000	200	25,600	24,300	14,200	22,000	1,25,800	71,700
Aug. 1st Week			28,200		1,13,400	1,44,000	98,100	1,79,900
Aug. 2nd Week	13,000		24,200	1,64,600	50,000		91,900	—
Aug. 3rd Week	24,500	87,400	90,800	32,800		17,000	—	75,800
Aug. 4th Week		24,000	6,000					—
Sept. 1st Week	22,000		16,200					14,000
Sept. 2nd Week			6,600					
Sept. 3rd Week								

This record will indicate that peak period of breeding when the largest number of eggs was consistently available was in August except in 1977 and 1978 when there was heavy rain in late July. Incidentally, the above records corroborates a similar forecast made earlier by the senior author (1971). It was seen that heavy collection of eggs usually coincided with heavy downpour of rain causing the streams adjoinning the lakes to swell and debouch large quantities of fresh rain water into the lakes.

Artificial propagation:

As is common with most of the cultivable species of carps, breeding of Mahseer with pituitary hormones was attempted but with limited success. This does not preclude the use of this method for artificial propagation. In fact, where the natural spawning grounds are difficult to locate, this would be the only solution. But its success would depend on the ecological conditions of the stocking ponds, the available food and the availability of sufficient stock of healthy and ripe brood fish. In Nainital hills (U.P.) stripping of ripe *T. putitora* (Ham.) was attempted in 1976 and eggs fertilised but heavy mortality during development was reported (Tripathi, loc. cit). However, our experience since 1970 indicated that if fishery biologists can locate the probable spawning grounds of Mahseer and can determine the peak of the spawning period with certain amount of exactitude so as to collect the ripe brood fish the stripping and fertilising the eggs artificially was more dependable. This latter procedure was followed in two lakes near Lonavla (Pune Dist.) namely Walwhan and Shirawta (*c.* 18°.45′ to 18°.40′N and 73°.25′ to 73°.29′E). They are respectively about 6.14 and 13.10 sq. km in area and 20 to 30 m deep. They are surrounded by hills all round and their source of supply is the seasonal streams flowing through the adjoining hills. The hills being steep and small, the flow continued only when heavy showers prevailed. The brood fish were observed to congregate at a short distance near the inflow of these temporary streams into the lakes. It was also observed that ripe fish congregated more during early part of the night say between 7 and 10 p.m. and again from 4 to 6 a.m. Netting operations undertaken during intervening period were comparatively less fruitful. Splashing of water or any nuptial play was rarely seen. In fact, actual natural egg laying (spawning) and fertilisation has not been seen except the reports of some observers, who describe the embracing act being similar to that of Rohu but in clear water and below the surface.

For the purpose of breeding operations, the spawning grounds are visited when it is raining and the streams are running. Suitable gill nets usually of 15 cm extended mesh are laid at 6 p.m. and hauled at 11 p.m. and 4 a.m. Ripe males and females, their ripeness judged by presence of milt in the male and soft bulged abdomen in the female are freed from the net by cutting some of the meshes. Other sex-determining characters are the peculiar obliquely protruding base of the anal fin of the female out of the curve of the ventral profile and the length of the pectoral fin in the male which have been detailed earlier (Kulkarni 1971). If the female is in the correct stage of ripeness, some eggs can also be seen extruding on slight pressure on the abdomen. Such ripe females are then stripped by the conventional method (dry process) in a suitable enamel tray and the eggs fertilised by the milt similarly obtained from the male. After two or three minutes, the excess milt is washed by adding and changing the water in the tray. The eggs have a tendency to stick to the surface of the tray but they can be carefully detached with the help of cotton wool and slight pressure. Water of the trays is then changed every half an hour and the eggs allowed to harden for next four hours. Thereafter they are placed in wooden trays, with plastic netting at the bottom and wooden sides (Fig. 2a). They are usually 55 × 35 × 12 cm high and are kept floating in a cement hatchery tank (photo 2) usually 2 × 1 × 1 m high (fig. 1). Each tray can accommodate about 30,000 eggs and being demersal they remain well arranged on the plastic netting about 4 cm below the surface of water. Clean tank water is continuously sprinkled over the eggs through perforated pipes running on the sides of the tank wall (fig. 1). Dead eggs, if any, are picked off with a pipette and the eggs kept clean. Excess water of the hatching tank overflows through a pipe having its opening (mouth) at the bottom by a siphon system, thus ensuring removal of less oxygenated bottom water. The eggs are thus bathed in well oxygenated water almost continuously although no harm is expected if the water is stopped intermittantly.

As mentioned earlier, it takes about 80 hours for the eggs to hatch out in water of about 22° to 26°C. temperature, the hatchlings remain in semi-quiescent stage for almost six days. This critical stage has also been highlighted earlier. The eggs which are bright lemon yellow or orange in colouration and measure 2.8 to 3.00 mm in dia. have already been described by the senior author (1971) along with other larval and post-larval stages. On the seventh day the fry swim freely (Fig. 2c) and start feeding on minute zooplankters like *Moina, Daphnia,* etc. After a day or two they start taking powdered groundnut cake and rice polish in small quantities. They are then shifted to cement nursery tanks and fed on zoo plankton as well as the artificial feed (groundnut cake) soaked in water. After making them accustomed to artificial feeding for about three or four weeks they are released into earthen nursery tanks for further growth. At this stage, the fry are about 30-35 mm in length and are suitable for transport over long distances in plastic bags in water and oxygen. Such consignments sent from Bombay to Bangalore showed no mortality. In about six to eight months the fry reach the stage of fingerlings and become suitable for stocking into perennial lakes or streams.

Transport of eggs in moist cotton:

As one of the measures to facilitate propagation of Mahseers into distant areas within

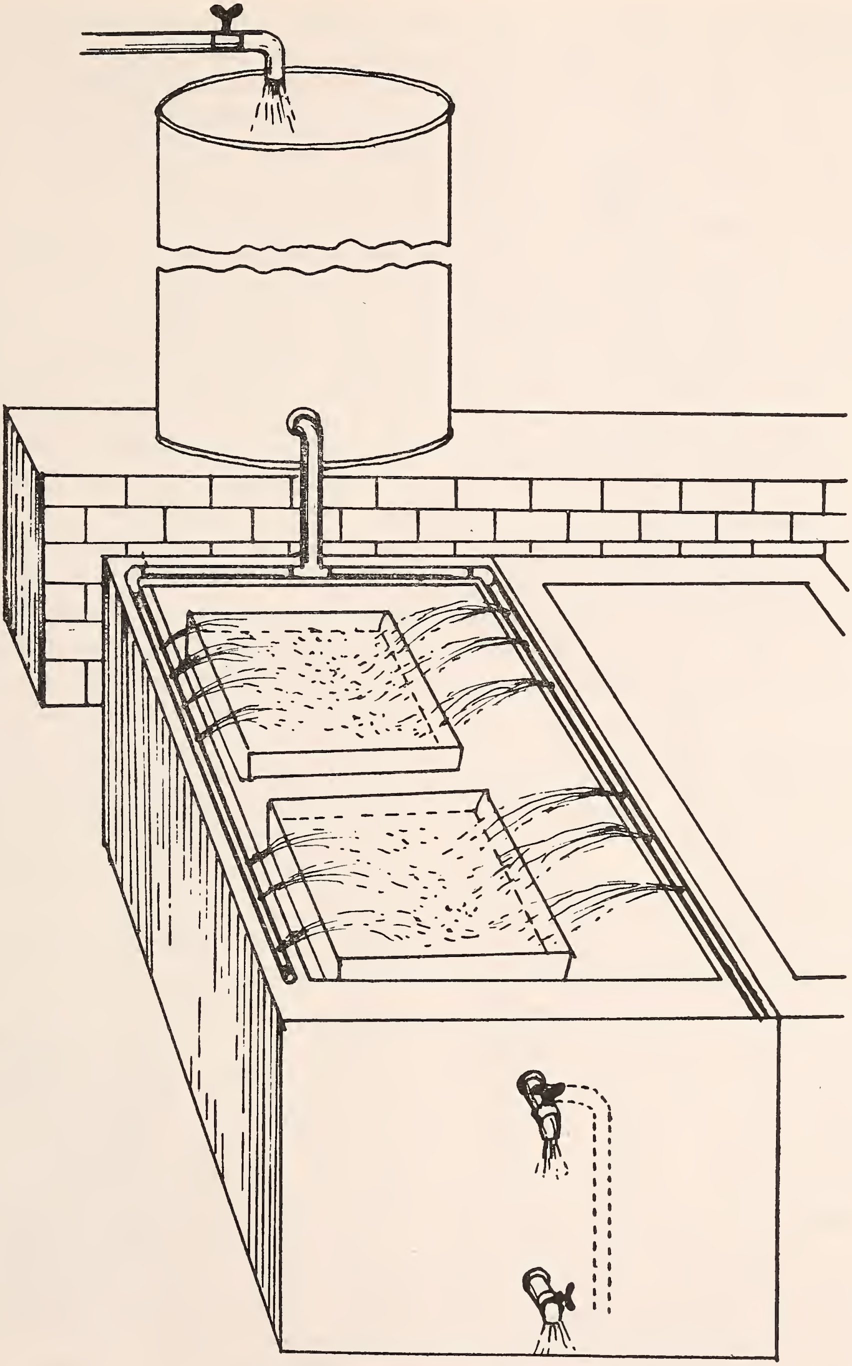


Fig. 1. Hatchery tank for Mahseer.

the country and abroad, an effort was made to pack fertilised eggs in moist cotton to ascertain whether they would remain viable, the idea underlying the experiment was to see whether they can be transported without water. Transport of "eyed ova" (fertilised eggs) of trout even across continents for their propagation in new environments is a well known practice and it is in this manner only that trout has been introduced in Kashmir, Nilgiris, Sri Lanka and many other countries. However, such effort has not been made so far with eggs of any of our other Indian fishes. This is probably because the hatching period in most of our common fishes is of short duration and the eggs are comparatively delicate.

To achieve the aforesaid objective of keeping eggs out of water, in moist packing, a small tray was selected and its bottom covered with moist cotton wool. About 40 eggs fertilised by the usual stripping method and water hardened from 6 to 24 hours were placed on moist cotton wool and covered by a layer of similar type of cotton. The tray (Fig. 2d) was kept in a laboratory room (air temp. 22°C) and after 24 and 48 hours they were taken out, released into water and hatched normally. Results of these experiments conducted in August 1977 were as under:

Batch No.	Period of water hardening	No. of eggs.	Period in tray	No. of hatchlings obtained.
I	12 Hrs.	30	12 Hrs.	26
II	6 Hrs.	40	24 Hrs.	36
III	6 Hrs.	40	48 Hrs.	37
IV	24 Hrs.	30	36 Hrs.	26

Observations in Batch II and III above are fairly satisfactory. The small variation in the number of hatchlings obtained in these batches after 24 and 48 hours may be due to the condition of eggs at the time of fertilisation or other factors commonly prevalent during the process of hatching which is as long as 80 hours. It is, nevertheless, significant that increase of period from 24 to 48 hours had no adverse effect on the number of hatchlings obtained, and indicated that 48 hour period was equally safe. Moreover, six hours seems to be an ideal period for hardening of eggs. but the longer period of 12 and 24 hours gave an opportunity to weed out unfertilised or damaged eggs, if any. Leaving aside the small variation, the results prove that eggs are capable of being kept in moist cotton and remain viable for at least 48 hours. As a field trial, two consignments, each of 5000 eggs were taken to Bombay Air Port from Lonavla, a distance of 100 km and parcelled by Air Bus to Bangalore unattended, in August 1978. They were packed in two layers of moist cotton in plastic baskets with an outer container of tin. In the first consignment mortality of eggs reached 8% upto Bangalore air port, whereas in the second, the mortality came down to mere 1.5%. About 75% of these eggs hatched out successfully. This experiment is the first of its kind in India and opens up new possibilities of transport of fertilised eggs, instead of fry, by air and then hatching them in the usual manner, thereby saving considerable expenses on transport in containers with water.

Further, if this method of packing of eggs is possible in the case of *Tor khudree*, there is no reason why it should not succeed in the case of *T. tor*, *T. putitora*, *T. mosal* and others. It is desirable that efforts should be made in their case also. If these experiments succeed, possibilities of exporting mahseer eggs to foreign countries which need them for purpose of culturing them as sport fish, can be ascertained and our esteemed Mahseer can have new homes outside India.

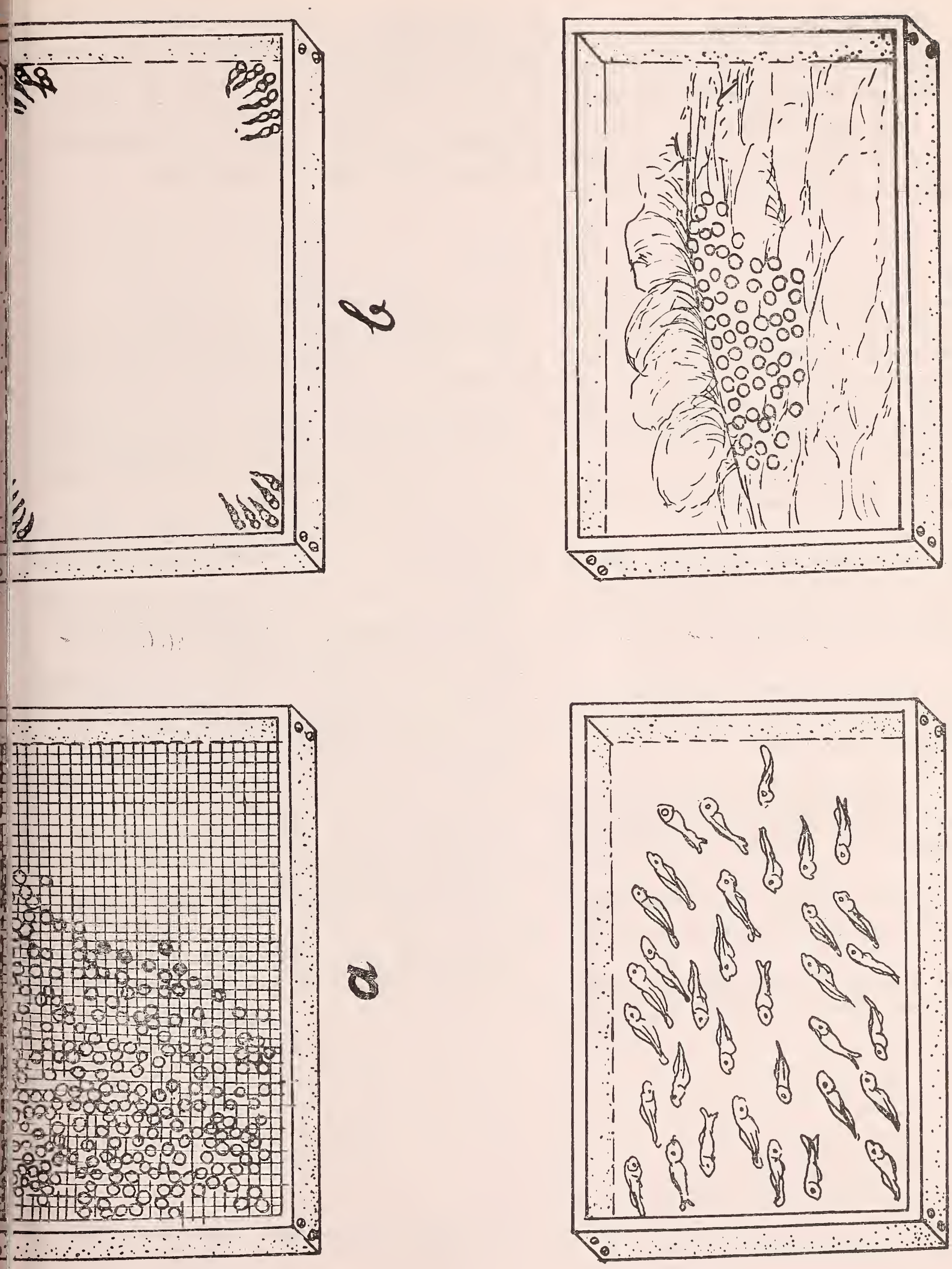


Fig. 2. a: eggs of Mahseer in a tray; b: hatchlings of Mahseer congregating in corners; c: free swimming fry; d: eggs of Mahseer in moist cotton.

ACKNOWLEDGEMENTS

We acknowledge our earnest indebtedness to the Tata Electric Companies for undertaking Mahseer breeding, conservation and rehabilitation activities for the first time in India and for affording all the necessary facilities for conducting the studies described in this paper, at Walwhan and Shirawta lakes near Lonavla. Co-operation of Shri M. Jayaraj, Director of Fisheries, Karnataka is also appreciated for kindly arranging, receiving and hatching of the eggs in Karnataka.

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OCEANOGRAPHIC RESEARCH IN INDIA—PAST, PRESENT AND FUTURE

S. Z. Qasim[1]

(*With a plate and a text-figure*)

Several physical characteristics of the seas around India were known to our ancestors since ancient times. Although they did not have a proper understanding of the phenomena like currents, tides and winds, they utilized their emperical knowledge, based on experience and visual observations, for practical purposes. For instance, the biannual reversal of the direction of winds has been known to Indians and the Arabs for centuries. This knowledge they cleverly used for crossing the Arabian Sea for trade purposes. Similarly, as early as the Indus Valley Civilization period, our ancestors were fully aware of the phenomena of ebb and flood tides. This is evidenced by the remains of an excellent dockyard at Lothal which the Harappans constructed to receive ships at high tides. Studies carried out on this dockyard suggest that the Harappan Engineers possessed sufficient knowledge of the tidal range, periodicity and the effects of tides. The Indians also had some knowledge about the animal life in the sea. This is clearly reflected from the *Ain-e-Akbari* and the Memoirs of several kings of the medieval period which give information on the fish and fisheries of Hindostan.

The origin of oceanography in India can be traced as far back as 1871 when an officer of the Indian Museum, Dr. J. Wood-Mason, was sent to Andamans to explore the fauna and flora of this region. He was perhaps the first person to carry out biological work in deeper waters off Andamans on board *S.S. Undaunted*. Immediately afterwards the Marine Survey of India was inaugurated in 1872. This was about the same time as *H.M.S. Challenger* sailed on her famous round-the-world cruises. Stimulated by the great success achieved by the *Challenger*, the Royal Asiatic Society of Bengal persuaded the Government of India to create a post of Surgeon-Naturalist to carry out work in Indian waters similar to that carried out by the *Challenger*. Thus in 1875, Dr. J. Armstrong was appointed as the first Surgeon-Naturalist. In 1881, a 580 ton survey vessel *R.I.M.S. Investigator* I was commissioned by the Marine Survey of India. On the request of the Government of India, the Admiralty agreed to give some of the equipment used on board *Challenger* for its use on *Investigator* I and thus the "oceanographic studies" in India began. These largely included biological collections, although occasionally observations on sea water temperature and bottom deposits were also made. *Investigator* I was scrapped in 1908 and replaced by *Investigator* II—a 1078 ton vessel, which was capable of cruising at faster speeds. However, it was not until 1910, when Col. R.B.S. Sewell took over as the Surgeon-Naturalist, that some observations on oceanography, other than biological studies, were started. These included the measurements of salinity and temperature of sea water, and some meteorological parameters like barometric pressure, air temperature using wet and dry-bulb thermometers and velocity and direction of the winds. Due to the First World War, the work was temporarily suspended from 1914 to 1921, before it finally came to a standstill in 1926. However, the surveys carried out in the Arabian Sea, Bay of Bengal, Andamans and Laccadive Sea, revealed a wealth of knowledge of the marine animal and plant life in waters of the Indian coast. These are described in excellent publications brought out by the Royal Asiatic Society of Bengal.

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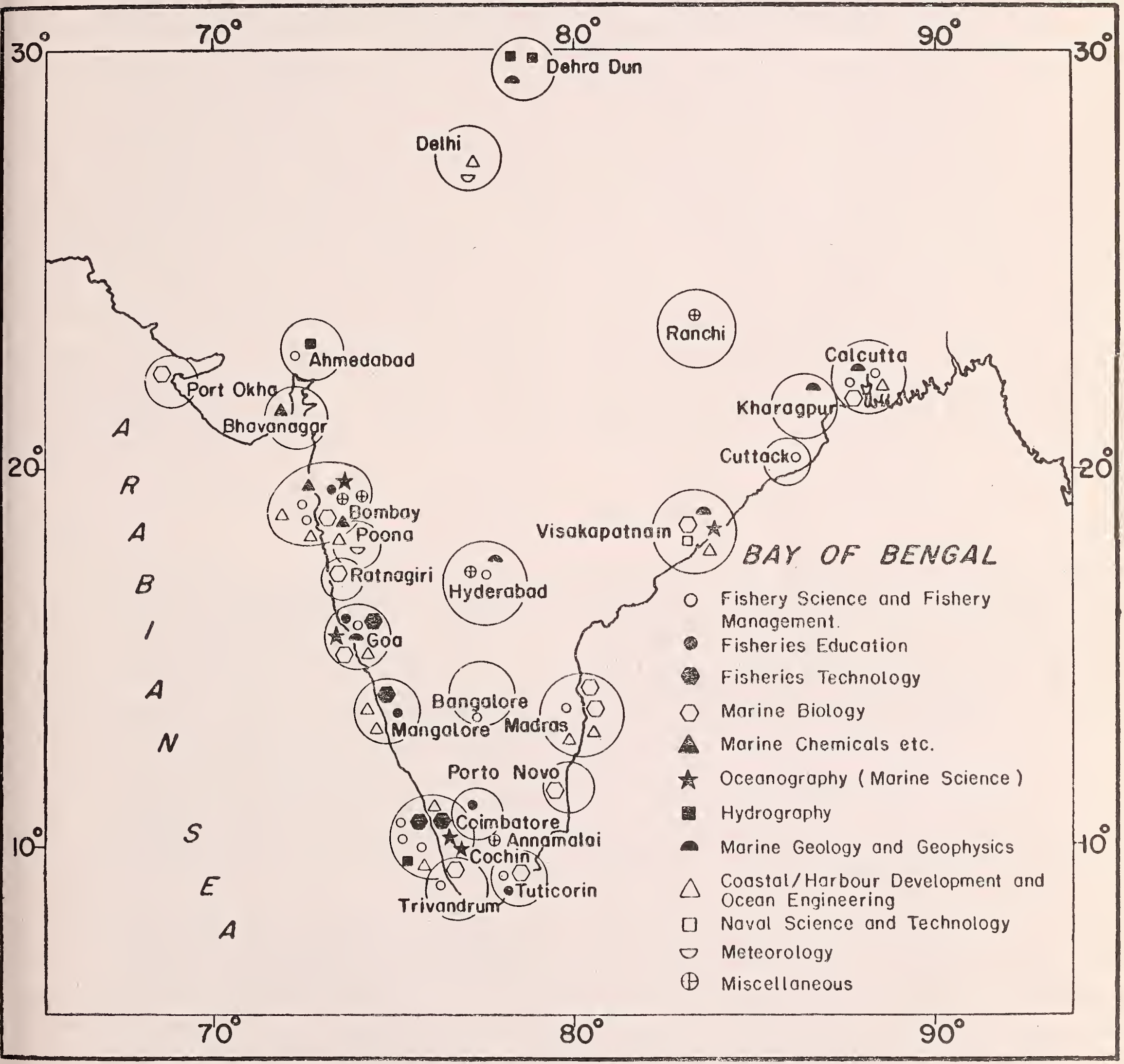
Useful oceanographic data continued to be collected by research vessels which crossed the Indian Ocean during the course of their global expeditions. These included the Dana Expedition (1928-30), the John Murray Expedition (1933) and the Galathea Expedition (1950-52). As a result of these expeditions many interesting features of the Indian Ocean became known.

After independence in 1947, the need for maximum utilization of the resources of the seas around India began to be realized. The early efforts were evidently directed towards "food from the sea". Thus, the Central Marine Fisheries Research Institute was established in 1947 to carry out researches related to fish and fisheries. In the following years analysis of sea water samples collected by the various Naval and Merchant ships was also included in the research programmes. The Indian Navy established a Naval Oceanographic Laboratory at Cochin for researches on defence-oriented problems. At the same time, oceanography and marine biology started to be taught in some universities at the postgraduate level. Commendable work on physical oceanography and meteorology was carried out at the Andhra University during the period 1952-1958 and researches on some more disciplines of oceanography such as geology and geophysics began to be undertaken for the first time in Indian waters. A Physical Oceanographic Wing was formed by the Central Board of Geophysics to carry out work on the physical aspects of oceanography.

However, thus far, a systematic approach to co-ordinate and expand the oceanographic work in India, according to country's needs, was lacking. Therefore, in 1960, the Government of India constituted the Indian National Committee on Ocean Research (INCOR) to meet some of the planning and coordination needs.

The International Indian Ocean Expedition:

Of all the world oceans, the Indian Ocean, even today, is the least studied. Most of the countries bordering the Indian Ocean are the most populous and at the lowest stage of economic development. It was, therefore, considered important to start this expedition so that new food and mineral resources could be explored for the benefit of these countries. Besides, the Indian Ocean poses several problems which are totally different from those of the other oceans. The land-locked nature of the Indian Ocean on its northern boundary and the bi-annual reversal of the direction of the winds known as the "monsoons" are the unique characteristics of this ocean. These considerations led to the development of a multi-national project, "The International Indian Ocean Expedition (IIOE)" co-sponsored by the UNESCO and Intergovernmental Oceanographic Commission (IOC). This expedition, in which 40 ships from 20 countries took part, started in 1962 and came to an end in 1965. A large amount of oceanographic data was collected from different parts of the Indian Ocean which helped in filling up the gaps in our knowledge of the seas around India. Because of the geographical position of our country and the scientific man-power it possessed, India became one of the active participants in the IIOE and played host to research vessels and scientists from different countries. Four ships from India took part in the Indian programme of IIOE. These were *I.N.S. Kistna, R.V. Varuna, R.V. Conch* and *M.F.V. Bangada*. However, the bulk of the data from the Indian ships came from *I.N.S. Kistna*, a 90 metre frigate of the Indian Navy which was specially refitted for oceanographic work. Scientists from different disciplines went regularly on board *Kistna*. As a result of this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⬡ Marine Biology
▲ Marine Chemicals etc.
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■ Hydrography
◓ Marine Geology and Geophysics
△ Coastal/Harbour Development and Ocean Engineering
□ Naval Science and Technology
▽ Meteorology
⊕ Miscellaneous

Location of institutions/organizations in India engaged in different activities related marine science and technology.

expedition, the country became aware of oceanography and developed a team of trained young scientists by the time the expedition came to an end. The expedition gave a firm base for the future oceanographic work in the country.

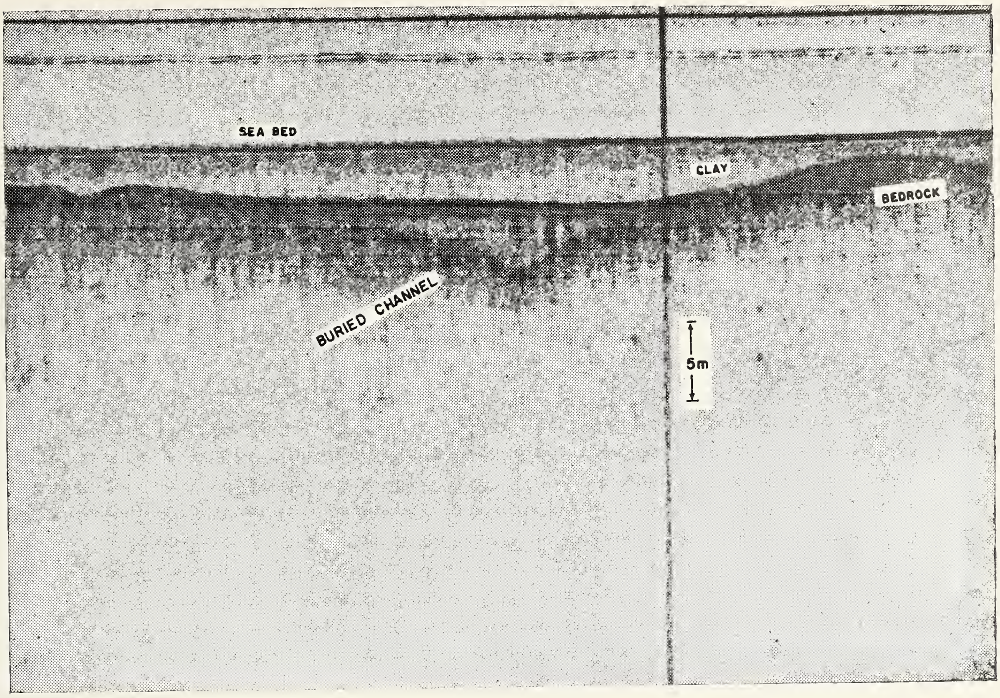
With the support of UNESCO and IOC, the Indian Ocean Biological Centre (IOBC) was established in 1962 at Cochin, for the study of zooplankton collected during the IIOE. The primary task of the IOBC was sorting of about 2,000 zooplankton samples, collected from the Indian Ocean, into various taxonomic components to be studied by specialists all over the world and also to store and maintain the archives of the samples. These tasks were successfully completed and the station data and displacement volumes of zooplankton samples were published in the form of several handbooks which also included the associated environmental data and research papers. The 10 atlases published by the IOBC summarise the distribution of the different planktonic groups in the Indian Ocean. These have been in demand throughout the world. The credit of most of the work done during the IIOE largely goes to the late Dr. N. K. Panikkar, who can be called the founder of modern oceanography in India.

PRESENT

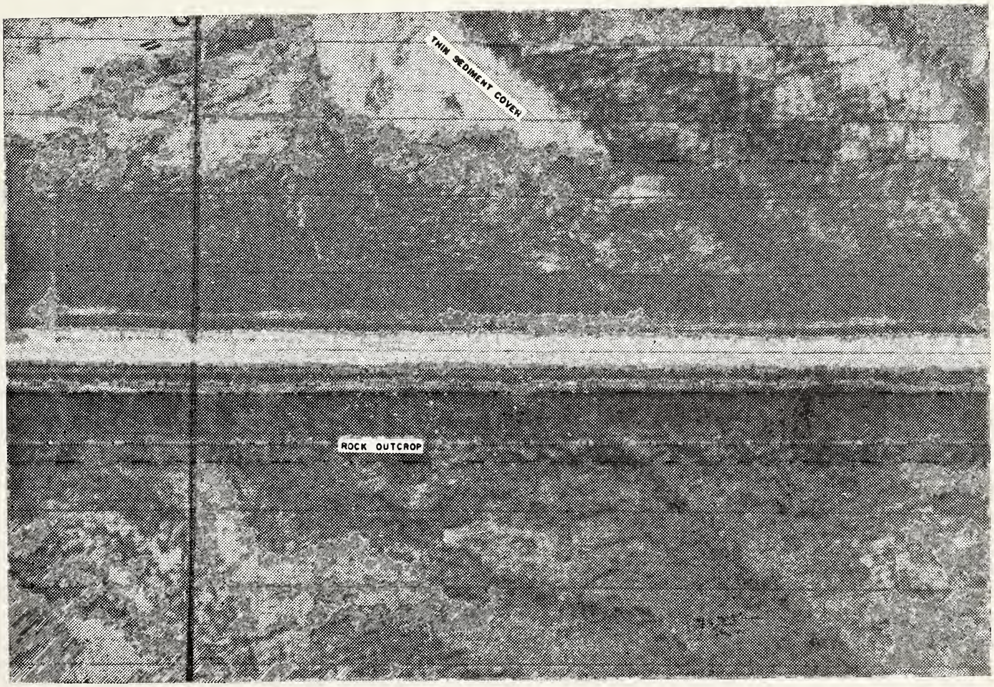
The National Institute of Oceanography:

The scope of the Indian National Committee on Oceanographic Research, which was initially set up by the Government of India for planning and coordination of the Indian programme of IIOE, was subsequently enlarged to cover all types of oceanographic activities in the country. This Committee strongly recommended that it would be in the national interest to consolidate the valuable experience gained from our participation in the IIOE and that an institute having the status of a national laboratory be established in the country. The Government agreed to this proposal and thus the National Institute of Oceanography (NIO) came into existence on 1st January, 1966 as one of the national laboratories under the Council of Scientific and Industrial Research (CSIR). With its temporary headquarters in New Delhi, the NIO took over all the activities which were earlier functioning under the Directorate of Indian Ocean Expedition. Over the years, the NIO has grown into a very sizeable organization. It has its Headquarters in Goa and three regional centres at Bombay, Cochin and Waltair. Today NIO has seven divisions which cover Physical Oceanography, Chemical Oceanography, Biological Oceanography, Geological and Geophysical Oceanography, Marine Instrumentation, Ocean Engineering and Planning and Data processing. It has a staff strength of about 425.

The greatest impact on Indian Oceanography came with the commissioning of the first oceanographic research vessel of NIO *R.V. Gaveshani* on 31st December, 1975. This ship, has a displacement of 1900 tonnes and is equipped with some of the most modern oceanographic instruments. These include salinometers, current meters, CTD systems, proton magnetometer, sound velocity meter, side scan sonar, survey sonar, submarine photometers, bathythermographs, continuous temperature and salinity recorder and continuous wave recorder, in addition to various types of gears for the collection of water and sea bed samples upto 6 km depth. *Gaveshani* is also provided with most modern navigational and communication systems including the Satellite Navigational System (SATNAV) for accurate position fixing. The ship has four well-equipped laboratories on board. *Gaveshani* provides



Vertical profile of the sea bed showing the main features obtained by a seismic equipment installed in *R. V. Gaveshani.*



Picture of the sea bed taken by *R. V. Gaveshani* using a side scan sonar. Sediment cover (sand and clay) is recorded in light-tone and rock outcrops in dark-tone.

air-conditioned accommodation for 19 scientists and 45 officers and crew and has an endurance of about 25 days.

To date, *Gaveshani* has completed 48 cruises in the Arabian Sea and Bay of Bengal resulting in the collection of a large volume of data and information on the seas around India which have contributed a great deal to our knowledge about the Indian Ocean. Uptill June 1978, *Gaveshani* has surveyed more than 50,000 line kilometres in the sea and has worked at 920 stations. These cruises have resulted in the location of several potentially rich fishing grounds in the Arabian Sea and Bay of Bengal in addition to mapping of the sea bed for mineral resources. Using this ship, NIO has done a substantial amount of work for the Oil and Natural Gas Commission (ONGC) connected with the exploitation of offshore petroleum.

During the last few years NIO has fully utilized the expertise and indigenous technology available and has provided service and support to a number of industries and public sector undertakings in as many as 50 sponsored projects on such areas as resources survey, harbour development, submarine pipeline surveys, pollution control and protection of coast from erosion. These sponsored projects are of direct interest to the user community.

Under the project "food from the sea", NIO has located several rich fishing grounds, has mapped seaweed resources and has developed sea farming technology. Under the project "coastal development", one of the most important contributions of NIO has been the survey of 160 kilometre submarine oil pipeline route from Bombay High to Bombay for the ONGC. This pipeline has already been laid along the route given by NIO and the crude from Bombay High has begun to flow. Two other surveys for the submarine oil pipeline routes are underway. These are from Bassein oilfields to Hajira (200 km) and from Bassein to Tarapur (120 km). These surveys are the first of their kind done by an Indian agency and are entirely based on indigenous technology. They have not only saved valuable foreign exchange but have given confidence and self reliance to the country.

Along the coastline, various activities such as harbours, power plants, oil terminals, hotels, tourist resorts and industries are fast developing. About 36 projects have been completed by NIO for the coastal development programme including a number of projects for the control of pollution in the sea. These have been sponsored by private industries and public sector undertakings. The work has been extended to coastal areas of Gujarat, Bombay, Goa, Karwar, Mangalore, Trivandrum, Madras and Visakhapatnam. Recently NIO has completed a large project on the disposal of sewage in Bombay waters for the Bombay Municipal Corporation.

The problem of oil pollution along the coastline of India has also become alarming in recent years. Large quantities of crude oil are transported from the Middle East to the Far East and other places across the Arabian Sea. A part of this oil gets into the sea due to accidental oil spills or due to the unlawful dumping of the residual oil or bilge from the oil tankers into the sea. When the volatile fractions of the crude oil evaporate, the residue acquires a form of tar-like lumps or balls. These tar-balls find their way to the coast and adversely affect the recreational value of our beaches. Since oil pollution is a world-wide problem, it is essential for the international agencies to develop proper conventions so that suitable measures are taken to curb this problem.

The international projects in which NIO is involved are: (i) Marine Pollution (Petroleum) Monitoring Pilot Project (MAPMOPP) under the framework of Integrated Global Ocean Station System (IGOSS) of IOC and (ii) Marine Environmental Monitoring and Marine Living Resources Assessment for the Indian Ocean Region under United Nations Environmental Programme (UNEP).

At present most of the instruments used for oceanographic research are being imported. Efforts are under way to develop some of the oceanographic instruments in the Institute to attain self-sufficiency in this field as far as possible. NIO has already developed instruments like current meters, salinometer, electronic sedimentation balance, bathythermographs and tide and wave recorder. Several other instruments like salinity-temperature and depth (STD) system are in advanced stages of development.

Besides NIO, several other organizations are also engaged in specific areas of research on oceanography, meteorology, marine biology and fisheries. Teaching and training are being done in the universities of Andhra, Annamalai, Cochin and Kerala. Sea fisheries research is being undertaken by the Central Marine Fisheries Research Institute, Cochin.

In recent years, the India Meteorological Department (IMD) has undertaken a series of observations in collaboration with USSR on the monsoon phenomenon. Preliminary studies conducted in 1973, known as the Indo-Soviet Monsoon Experiments (ISMEX), gave very interesting results. These are now being followed up by studies on a much larger scale. This project, called as Monsoon Experiments (MONEX), will help in understanding the phenomenon of monsoon whose appearance and disappearance have so far remained a riddle to meteorologists. In 1977, India carried out the Monsoon Experiment jointly with U.S.S.R., but in the forthcoming MONEX-1979, several countries are participating and about 10 ships including *Gaveshani* will be fully involved in the programme.

THE FUTURE

Oceanography, the collective entity of all sciences, is relatively a young science for India. Considerable work has been done within a short period of about 12 years, during which time most of the infrastructure and manpower requirements have been built up. However, whatever has been done is a small fraction of what remains to be achieved. With the recent declaration of 200 nautical miles of Economic Zone, we have added a very large area, about 1/3 of the total land area of India, to our economic limits in the sea. This area needs to be intensively explored for the living and non-living resources. India's future oceanographic programmes are being planned to suit many urgent needs. With the discovery of oil off Bombay, a new era of oceanographic exploration has started. The vast continental shelf off the Indian coast must be extensively explored to locate similar structures. Search for offshore oil is likely to be intensified in the near future. NIO, being fully conscious of its responsibilities, is going to be actively involved in such studies. Major developments in the offshore oil exploitation are expected to be in the field of ocean engineering and technology. Offshore drilling platforms and sophisticated buoy telemetering systems for continuous data acquisition would have to be developed indigenously for successful exploitation of offshore oil. Similarly, a considerable amount of work will be carried out on the design of foundations of the structures to be built at sea.

Another field of potential importance is the optimum utilization of marine mineral resources. For this purpose, NIO is working in collaboration with the Geological Survey of India (GSI) and the survey of almost the entire western continental shelf has been completed. More intensive studies are planned in the Bay of Bengal and in selected areas of the Arabian Sea. Deeper regions of the Indian Ocean are very rich in manganese nodules. It is hoped that very soon the country will be able to build up the necessary competence for the exploration and exploitation of manganese nodule.

The utilization of marine living resources is another area in which considerable effort will be put in, and for this, aquaculture or sea farming technology is going to create the greatest impact. Besides food, animals and plants of the sea are going to be used for many other purposes. Several important chemicals are likely to be obtained from seaweeds and marine animals such as corals, sponges, etc. These organisms are known to possess very interesting biologically active compounds which are different from those obtained from the land plants and animals so far. These chemicals have a rich potential for being developed into important drugs and pharmaceuticals. Realizing the importance of such studies, NIO has taken up a project on "drugs from the sea" in collaboration with the Central Drug Research Institute (CDRI), Lucknow.

It is known that most of the conventional sources of energy (fossil fuel) are exhaustable and hence many countries of the world are now seeking alternate sources of energy which will be unconventional and inexhaustable. Significant progress has been made in several countries including India for the utilization of energy stored in tides, waves, currents and temperature difference of water column in the sea. Preliminary studies carried out indicate that some areas of our country are very promising for harnessing tidal energy. Researches on this important aspect is likely to draw more and more attention during the forthcoming years.

The most significant contribution India will make during the next decade or so would be in becoming self reliant in undertaking the different challenging tasks of exploiting the sea and its resources for the benefit of its people. India will also provide support and expertise to many developing countries of the world in the field of ocean science and technology. The oceans will thus continue to hold the promise of meeting man's evergrowing needs for food, minerals, energy, chemicals, water, living space and climate. The new age into which we are moving in is not only the age of atoms, the electron and space, it is also the new age of the sea.

THE STATUS OF THE GHARIAL (*GAVIALIS GANGETICUS*) IN U.P. AND ITS REHABILITATION

V. B. Singh[1]

(*With a plate and two maps*)

INTRODUCTION

Not very long ago, several rivers in U.P. had a good number of gharials. In the course of short period of about fifteen to twenty years, there has been drastic depletion in their population so much so that some of the rivers, have been completely denuded. The situation has become alarming and the gharial is almost on the verge of extinction in this State.
A variety of causes contributed to the large scale destruction of gharials. Some of these are (i) Lack of enforcement organisation. (ii) Indiscriminate shooting and netting. (iii) Use of nylon gill nets for fishing. (iv) Construction of reservoirs and barrages and (v) Removal of eggs by tribals and local people for use as food.

A study of gharial population in Uttar Pradesh was initiated from Jan. 1975 onwards and three main rivers namely Ganga, Sarda and Ghaghra were surveyed. It was also decided to construct hatchling ponds so that eggs collected from nature could be hatched and reared at the rehabilitation centre. The intensive survey yielded solid results in the form of a clutch of 38 gharial eggs which were collected in April 1975 from the west bank of the river Girwa near Katerniaghat in Bahraich District. These eggs were transported to Lucknow for artificial incubation, hatching and rearing of the young. Twenty one of the eggs hatched and these were kept in two ponds constructed according to our own design and plan. The centre was visited by the FAO expert and we discussed in detail the entire problem of gharial rehabilitation in U.P. and worked out a scheme, incorporating the following main features:

(i) Detailed survey of the existing crocodilian population in the State.
(ii) Based on the information collected through survey, to translocate isolated populations; to protect the viable populations and to locate nesting sites.
(iii) Establishment of breeding Centres.
(iv) Essential research on the ecology of crocodilians which will provide basic data about their breeding growth, food habits, population etc.

With financial aid from the Central Government for the execution of the scheme, notable progress was made towards achieving the four objectives. We have surveyed our rivers, located breeding populations and nesting sites; collected eggs, hatched them and reared the juveniles at our rehabilitation Centres. We have at present (August 77) the largest gharial population anywhere in the World. In this paper, however, the results of the survey to determine the status of gharial and the efforts made to rehabilitate this species in nature by rearing them at the Centres is reported.

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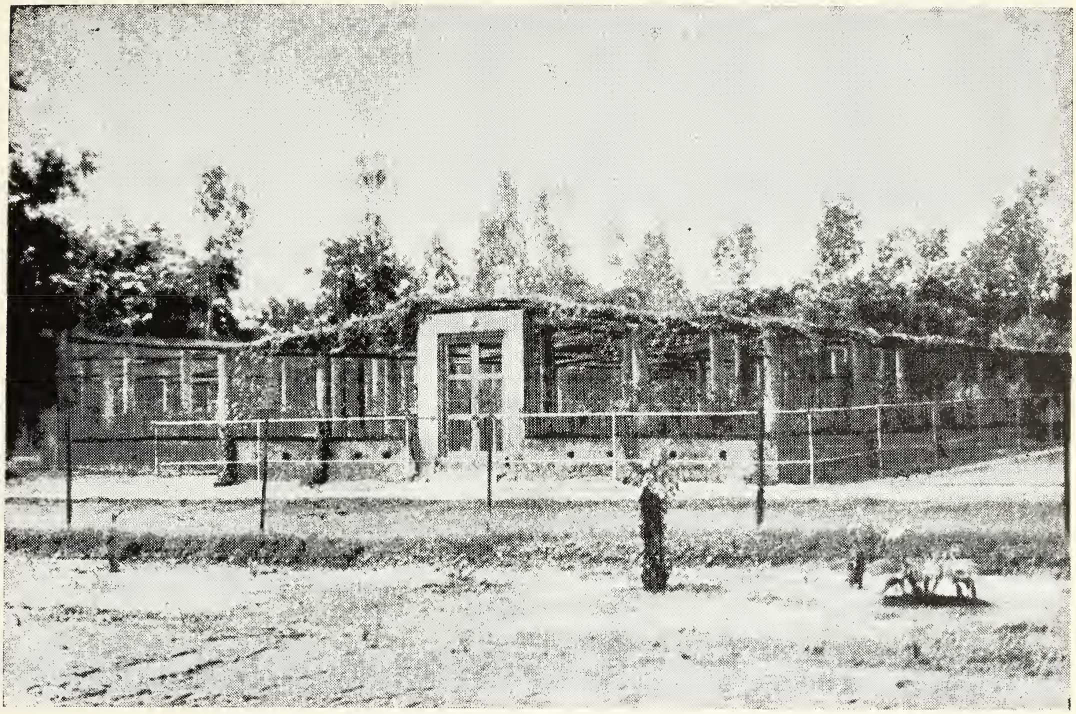
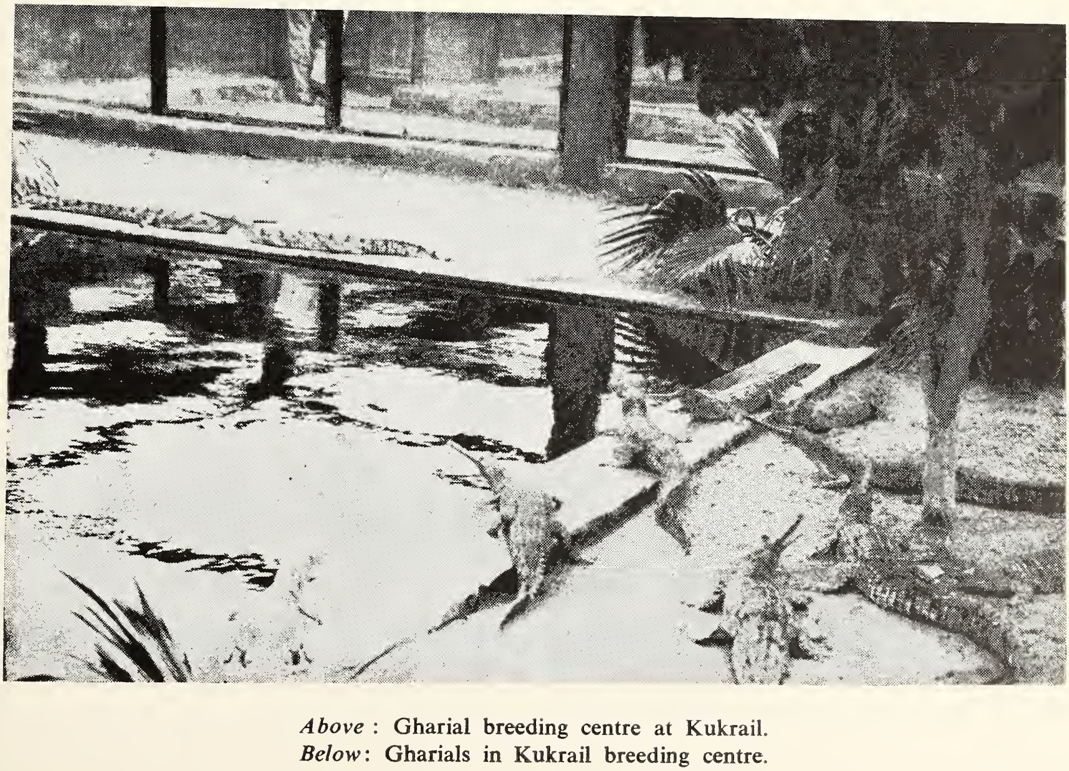
[1] Chief Wildlife Warden, U.P.





Above : Gharial breeding centre at Kukrail.
Below: Gharials in Kukrail breeding centre.

II. STATUS SURVEY OF THE GHARIAL IN THE RIVERS OF UTTAR PRADESH

Methods

The survey team consisted of a surveyor, two assistant Surveyors and 3 boatmen. Other than the surveyor, the rest of the staff are members of *Mallah* community, who are very familiar with the habits and natural history of river animals. The two Assistant Surveyors have been employed under this scheme as regular Government employees and the rest worked on daily wages basis. Two boats were constructed, one for the river Chambal and the other to be used in Girwa river. Survey of other rivers was done with the help of boats taken on hire. Valuable information about the location of gharials was obtained from local fishermen through our staff.

Two 7 x 50 binoculars were used and census figures are based mostly on day counts of animals seen. Day census is often as effective as night census though hatchlings and juveniles showed up mainly during night counts using three-cell torches when they were feeding near the shore, adults were never spotted during the night.

Survey Reports:

Narayani or Gandak river

The Gandak river (Narayani) after leaving Nepal flows through the Doma forests of Nichlaul Range in Gorakhpur district along the U.P.-Bihar border. A large population of Gharial used to be found here. Thomas W. Webber in his book THE FORESTS OF UPPER INDIA (1902) mentions seeing groups of 20 or more basking in the mid-river sandbars. In addition he also mentions that mugger used to abound in jheels and tanks around Gorakhpur itself.

Two to three animals were reported seen in 1975 near the Tailfall gate on the main Gandak West Canal. Two gharials both without nose humps about 2.5 to 3 metres in length were seen in the canal itself but during a period of high water, when the gate was open, one had moved away.

The Irrigation department official who resides near the gate sighted this remaining gharial basking on the sand bank of the canal between 1100 and 1600 hours. During the lean period of the river before the monsoon begins in late May, Gharials are seen in the Gandak river which then flows through a narrow channel on the Bihar side of the border. During this period they are sighted in small numbers (less than 5) at the Gahanu and Bhainsaha ghats. There was one reliable report that the area was visited by a gharial with a nose hump during the first floods in June/July but it has not been seen recently.

Gharials in this area have become rare because of altered habitat conditions arising from diversion of Narayani water in the East and West Gandak canals. As a result of this, the Gandak had become a spent force resulting in the *'Kunds'*[2] in the river gradually getting silted up, thus greatly reducing the *habitat* where most riverlife resides in summer.

It is worthwhile noting that the presence of gharial in the canal represents normal high water behaviour of gharial when they leave the swollen main river and seek refuge in a tributary in this case a canal connected to the Narayani.

Ghaghra river—Enquiries from fishermen at Ghaghraghat and Dohrighat revealed that gharial which were formerly abundant have now been depleted to the point of extinction in the lower Ghaghra and no adult animals have been seen here for more than a decade.

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[2] Deep pools in the river bed.

Fishermen at Dohrighat claimed that migrants are seen immediately after the high water season though the frequency of such sightings have also gone down sharply in recent years. That the Gharial is not yet completely extinct is shown by the fact that the survey party was able to acquire a 1.3 metre long juvenile from a fisherman in October 1975. This animal died after about 3 months in captivity being unable to adjust to captive conditions. Small numbers of gharial used to be exhibited at Dohrighat during the *Kartik* festival held there each year. A superstition based ritual used to be performed on these animals which were later released in the Ghaghra. In 1975 it was seen that turtles had replaced gharial as the object of ritual due to the current rarity of gharials.

It is estimated that over the entire length of Ghaghra there are possibly five isolated gharials.

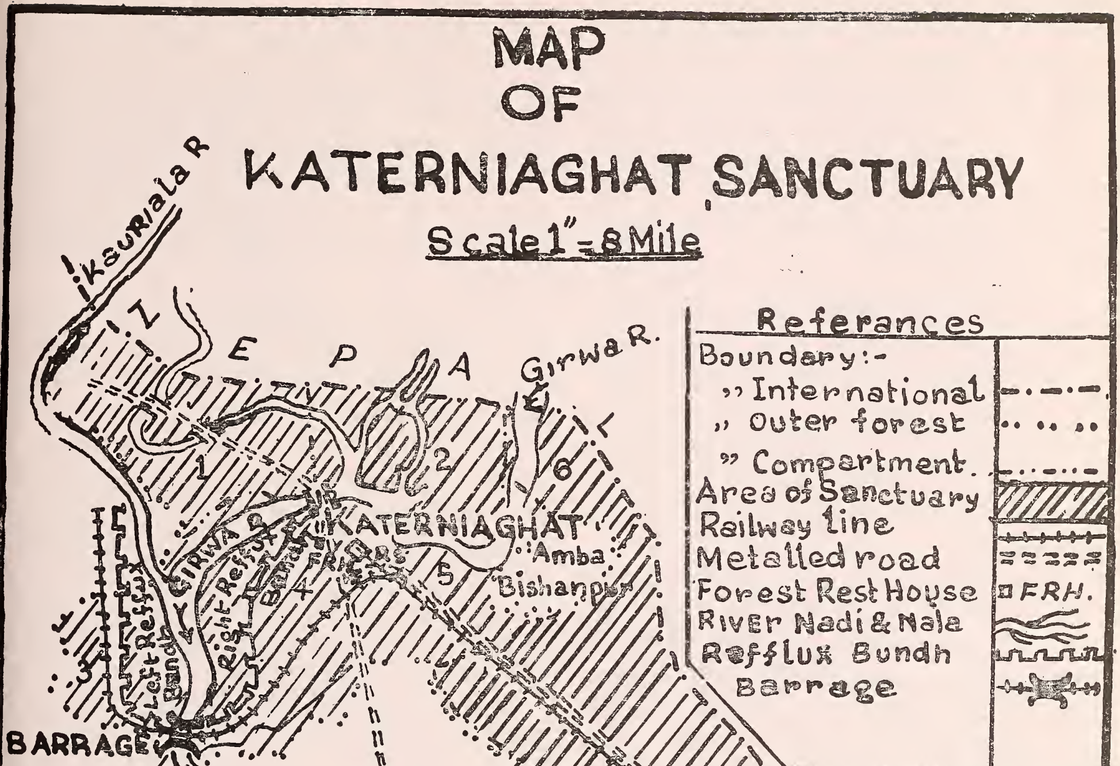
Girwa river—Girwa river which is known as *Karnali* in Nepal before it enters the Indian territory lies in Katerniaghat wildlife sanctuary. From the point of its confluence with Koriala downstream it is known as Ghaghra, about which details have been given in the para above. The stretch of 18 km of Girwa river is at present the best gharial habitat in the State as 5 km stretch of this river has the largest population of gharial in the country.

The population of Girwa was surveyed between March and May 1975 when 14 gharials including one hump nosed male were counted. During surveys in 1976, 25 gharials including 3 hump nosed males and 7 adult females were seen. The sudden increase in the population observed since the receding of the river after the monsoon season of 1975 is attributed to migrants who have moved into the area from the Karnali gorge, Cheesa Pani in Nepal due to increasing disturbance there arising from surveys for the Karnali Dam Project. Another important reason could be less disturbed basking areas available in this part of the river due to reduced human disturbance, as this year there was no working for timber in the surrounding forests and boats carrying driftwood were absent.

Formerly the gharial was more widely distributed along the entire length of the Girwa downstream of the Nepal border at Katarniaghat. Gharial also occurred at the confluence of the Kauriala and Mohan river and in the Mohan river itself. But at present they are mostly restricted to a 3-5 km stretch of the Girwa adjoining compartment 2 from about one kilometre above the temporary bridge at Katerniaghat. Gharials occasionally show up to the confluence of Girwa and Kauriala and the Kauriala and Mohan rivers after the monsoons but there is a tendency to abandon these areas during the subsequent months.

The details of the gharial population in the Girwa is therefore as follows:

(i) Male	2	17 feet and 20′-21′ long
(ii) Female	7	Adult 10′-15′ long
	2	adult reaching breeding size
(iii) Sub-adults	4	6′ to 10′ long
(iv) Juveniles	11	5′ to 7′ long
(v) Young ones (two years)	2	3′ to 5′ long
Total:	28	


MAP
OF
KATERNIAGHAT SANCTUARY
Scale 1" = 8 Mile
Kaurialā R
N E P A L
Girwa R.
1
2
6
3
4
5
8
KATERNIAGHAT
FRH
Amba
Bishanpur
Girwa R
Left Refflux Bandh
Right Refflux Bandh
BARRAGE
GAGRA RIVER
Nishangar
Dharmapur
FRH
Dharmapur Jhil
SARJU RIVER
FRH
Referances
Boundary:-
" International
" Outer forest
" Compartment
Area of Sanctuary
Railway line
Metalled road
Forest Rest House
FRH.
River Nadi & Nala
Refflux Bundh
Barrage

Chambal river—The river Chambal forms the border between U.P. and Madhya Pradesh for over a length of nearly 250 kilometres. During the period December 75 to January 76, nearly 200 kilometres of Chambal in Uttar Pradesh was surveyed. The survey started by boat from Samruna ghat just above the U.P. Rajasthan border downstream to the pontoon bridge at Sahson Ghat.

The Chambal is generally a deep river flowing between high banks. There are numerous bends where the river is over hundred feet deep. The extensive river habitat of the Chambal supported a large population of gharial and other river life in the past. Indiscriminate hunting and netting has brought the population down to a stage where its survival has been threatened.

A flayed body of an adult male was seen on the banks of a *Kund* close to Ridauli village on the right bank of the river which lies in M.P. The carcass which had not yet begun to decompose belonged to a 17 feet humped gharial which had been stripped of its skinned hump on the nose. Local people reported that it was shot after 5th December by the Chawkidar of Ridauli village in M.P. Tracks of gharial which had come out to bask belonged to more than one gharial. Near Basauni village in U.P. two small springs which originate in small ponds flow into the river. Here gharials below three metres in length were reported to be trapped since the water receded from the ravines after the monsoon flood. One of these was killed with sticks when a farmer was surprised by the animal as he was washing his hands in the pond.

Several tracks of adults were seen on the submerged portion of a mud bank above Aterghat. Three (3) fresh tracks of juveniles or sub-adults were seen on a mud-bank close to Mau village in M.P. on the right bank. One juvenile below 1.5 metres in length was seen near Kasaua village on the right bank in M.P.

In the stretch of the river surveyed the number of adult gharials will not exceed 10. In addition sub-adults and juveniles occur in fair number. This is stated on the basis of information collected from villagers working close to the banks of the Chambal. However, the gharials could not be sighted for the following reasons:

(i) Gharials in Chambal come out of water less frequently during December and January and are seen more often before November and after mid February to May.

(ii) Very intensive commercial fishing is done in this river and as many as 25 boats were found operating in the stretch of the river surveyed. Gharials do not come out because of this activity.

(iii) Old adults are very shy and do not completely leave the water but bask by resting their snouts only on land.

(iv) In many places mid river rocks are used for basking and no tracks are left on these.

The river still provides good habitat for gharial, they have disappeared mainly due to hunting. Numerous methods of hunting have been adopted. The important ones are: a) Shooting, b) netting, c) by hooks planted in the sand, d) noosing of juveniles, e) spearing by torch light.

They are also caught accidentally in fishing nets and turtle hooks. A secondary reason may be increasing human activity near the river as indicated by the existence of greater number of ferries on the Chambal than shown in the earlier editions of survey of India maps.

The portion of the Chambal river upstream of U.P. border between Rajasthan and M.P. still contain breeding populations of gharial. Our survey work continued in this part of the river as well but its details will form part of another note.

It is however considered necessary to give the abstract of results so that the actual status of the gharial in the country may be assessed. The following are the details of the population observed in this portion.

Male	— Adults	—	6
Female	— Adults	—	12
	Sub-adult	—	15
	Juveniles	—	16
	up to two years	—	34
		Total	83

The breeding population of gharial in this part of the Chambal gave us during the 1977 egg laying season as many as 12 clutches of 497 eggs. It is therefore justifiably believed that gharial will naturally increase in the U.P.-M.P. portion if their hunting and extermination are completely eliminated.

Ramganga river — Ramganga river flows through the Corbett Park. This river debouched into the plains at Kalagarh where a dam has been constructed. It has created a reservoir of nearly 80 square kilometres, submerging the best gharial pools which existed in the river in a stretch of 8 kilometres upstream of Kalagarh. Till 1960, this river had a very large gharial population which could be seen basking on islands and sand bars. The census carried out in 1965 indicated the presence of atleast 15 adult gharials. The construction of the dam, which involved heavy dynamiting of the hills and river banks was responsible for the destruction of the gharials. Now the total population consists of 5 adults, of which two are males and three females. All the gharials live in the pools lying in the stretch between Dhikala and Gairal, a length of nearly 25 kilometres. They share pools with muggers which are more common in the river now.

Ramganga below Kalagarh is almost a dry river on account of the Kalagarh reservoir. Only a few isolated gharials have been reported in Bedaun and Shahjehanpur districts.

Ganges river—The portion of the river above Garh Mukteswar is not habitable for gharial due to lack of deep pools and paucity of water.

(i) Between Garh Mukteshwar and Kanpur no gharials were observed but reports about the occurrence of several isolated adults have been received.

(ii) Between Kanpur and Allahabad—in this portion gharial has been completely exterminated and no reports about their existence anywhere were received.

(iii) Between Allahabad and Mirzapur—occasional reports of isolated adults have been received till recently.

Jamuna river—Below its confluence with Chambal river, some juveniles have been seen occasionally. Sometimes migrants from Chambal stray into Jamuna and isolated adults have been seen in certain areas.

Betwa river—Gharial habitat has been badly disturbed in this river due to the construction of various hydel and irrigation projects. The population is accordingly either extinct or near extinction.

Ken river—Gharial is extinct in the portion of the river in U.P. A few are reported to survive in the higher reaches in M.P. but they are cut off from U.P. by an irrigation barrage.

Son and Tons rivers—Gharial is reported to survive in the river gorges in M.P., but they are almost exterminated in U.P. These rivers used to have a good number of gharials some years back. Only occasional migrants may stray into the U.P. portion of this rivers.

Rapti river—No resident population survives in the U.P. portion of the river. In the portion in Nepal, there are several breeding adults. Occasional migrants may stray into U.P.

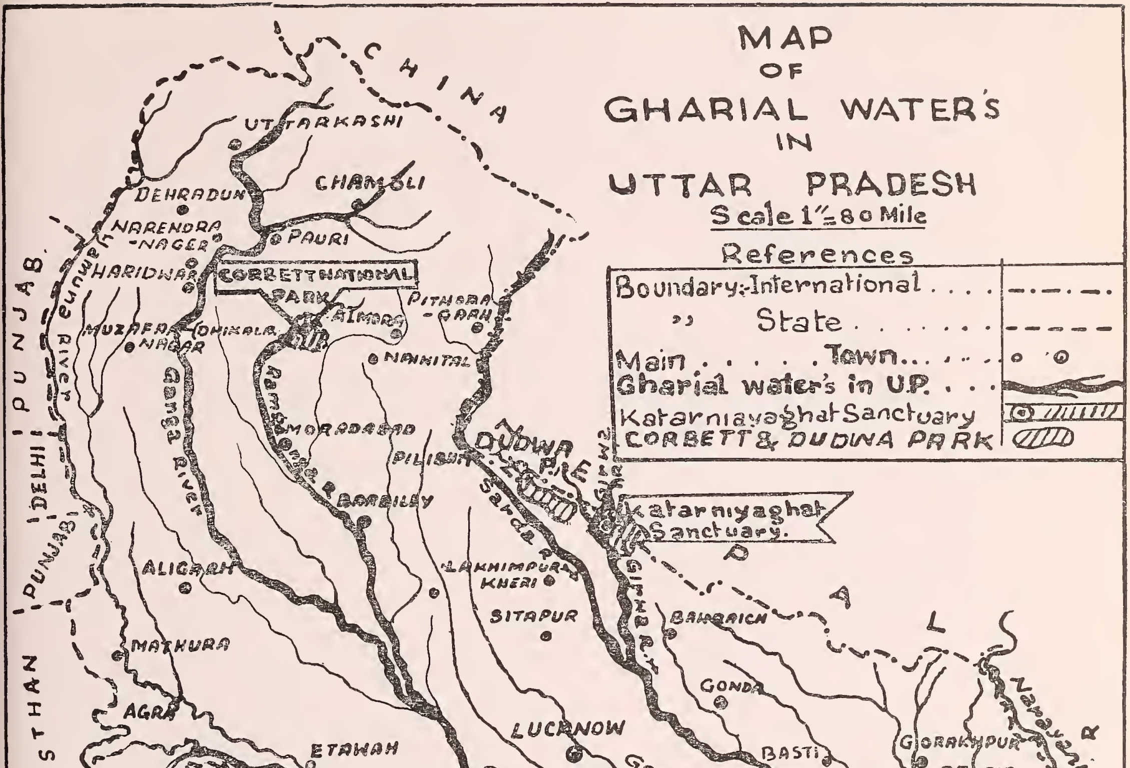
The following is the abstract of gharial, populations in the rivers of U.P.

(i) Narayani	2	Sub-adults
(ii) Ghaghra	5	adults (isolated)
(iii) Girwa	2+9	adults
	17	sub-adults & young ones
(iv) Chambal		
(a) U.P.	10	adults (isolated)
(b) M.P./Rajasthan	6+12	adults
	65	sub-adults & young ones
(v) Ramganga		
(a) Corbett Park	5	adults (isolated)
(b) In the plains	4	adults (isolated)
(vi) Ganges	4	adults

Conclusion—The results of the survey as given earlier bear testimony to the fact that gharial is uniformly rare to the point of being extinct in most of the rivers in U.P. which not very long ago supported a sizable population. The only breeding population in the entire State exists in the Girwa river of Bahraich Forest Division. The resident population here consists of nearly 30 individuals including 9 adult females and two (2) adult males, the remaining being sub-adults or juveniles. So far only a maximum of four females have participated in nesting. In all other rivers, only isolated individuals may continue to survive, but these are not believed to be of breeding status. Also in case where the upper reaches of rivers lie outside the State boundaries and in which gharial continues to survive, flux of migrating individuals specially juveniles may sometimes be observed after monsoon floods. Reports of such remnant population continue to be received from the river Ghaghra, Ganga between Garh Mukteshwar and Kanpur, the Ramganga, Chambal, and Jamuna rivers.

GHARIAL REHABILITATION PROJECT

Less than 1% of all gharials hatched in nature reach a length of two metres after which they generally become immune to predation. One breeding female may lay eggs from 20 to 100 in a clutch, which is a sufficiently large number to maintain a population if a fair proportion out of them could survive to reach the breeding age. But the eggs and hatchlings fall victim not only to predators like fish, jackals, monitor lizards, birds of prey or even big gharials but also to egg eating tribal communities. All odds were against the rehabilitation of gharials in nature with its rapidly shrinking habitat, the fast flowing and deep pooled rivers being favourite sites for dams, barrages and reservoirs, and the ever present threat of hunting by hooks, rifles, dynamite or nets for their valuable hide. Also young and old alike were being accidentally enmeshed in huge nylon fishing nets and either drowned or were clubbed to death to save the valuable net. There was little hope of rehabilitating the gharial without a crash programme to overcome these difficulties and adverse factors. A project which could take care of protection and which could produce sufficient number of gharial babies to repopulate the rivers was the


MAP
OF
GHARIAL WATER'S
IN
UTTAR PRADESH
Scale 1"=80 Mile
References
Boundary:-International
" State
Main Town
Gharial water's in U.P.
Katarniayaghat Sanctuary
CORBETT & DUDWA PARK
CHINA
UTTARKASHI
CHAMOLI
DEHRADUN
NARENDRA-NAGER
PAURI
HARIDWAR
CORBETT NATIONAL PARK
DHIKALA
ALMORA
PITHORAGARH
NAINITAL
MUZAFAR-NAGAR
Yamuna River
Ganga River
Ramganga R.
MORADABAD
PILIBHIT
BAREILLY
DUDWA P.
Sarda R.
Girwa
Girwa R.
Katarniyaghat Sanctuary
PUNJAB
DELHI
ALIGARH
MATHURA
AGRA
RAJSTHAN
LAKHIMPUR KHERI
SITAPUR
BAHRAICH
NEPAL
GONDA
LUCKNOW
BASTI
GORAKHPUR
DEORIA
Narayani R.
ETAWAH
Chambal River
KANPUR
Ganga River
Gomati R.
Sai River
RAIBARELI
SULTANPUR
Ghaghara R.
AZAMGARH
BALLIA
ORAI
Betwa R.
JHANSI
BANDA
Yamuna River
ALLAHABAD
VARANASI
MIRZAPUR
MADHYA PRADESH
Son R.
DUDHI
BIHAR

need. These objectives could be achieved by:

(i) Careful collection of eggs from the wild, their artificial hatching combined with captive rearing of the young till they attained a length of nearly 2 metres when they were strong enough to fend for themselves and survive in nature against most of the predators.

(ii) Creation of sanctuaries to protect the existing breeding population.

Pilot Project: The Wildlife Preservation Organisation of Uttar Pradesh decided to start a pilot project to construct breeding ponds and to collect eggs, hatch them and rear the young ones. It was decided to survey rivers to locate breeding populations so that during the egg-laying season likely nesting sites could be watched and eggs collected for our rehabilitation centre. While the preliminary survey was being conducted from December 1974 to January 1975, information was collected about the design and specifications of ponds.

Kukrail reserved forest, which covers an area of nearly 2000 hectares and is located 12 km away from the State Capital Lucknow was selected as the site for the location of the rehabilitation centre. The river Kukrail is perennial and can provide sufficient fish of all sizes for most part of the year and was the main attraction in addition to the closeness of the place to Lucknow which made intensive and frequent inspection of the centre possible. In an enclosure of 12 x 6 metres which was enmeshed on all the four sides and on the roof, two ponds each of 2.25 x 1.90 x 0.4 metre size were constructed with inlets for running water from a tubewell and drain pipes to clean the ponds.

Systematic surveys carried out in February 1975 proved successful and atleast 14 animals were enumerated in the Girwa river near Katerniaghat in Bahraich district. Our staff managed to locate a single nest of gharial which yielded 38 eggs which were transported in May 1975 to Kukrail for artificial hatching. Twenty one (21) hatchlings emerged in the first week of July out of which one died immediately and the rest were released into the newly built ponds. The centre was visited by the crocodile expert of the FAO/UNDP on the 5th August 1975 and at his suggestion 10 of the hatchlings were sent to the Orissa Rehabilitation for rearing under his supervision. The remaining 11 were kept at Kukrail. Proper arrangements had to be made to protect the hatchlings against winter. The entire enclosure was covered by polythene sheets and jute mats to ward off cold winds and to arrest sun's heat. Electric room heaters were provided for keepin the water in the ponds above 18°C below which hatchlings in captivity tend to become lethargic and susceptible to diseases.

Our experiment in artificial rearing proved successful and at the end of the year 12 hatchlings had survived 8 in U.P. and 4 in Orissa.

Encouraged by this success we presented a full fledged scheme to the State Govt. under which the Central Government was requested to meet the capital expenditure and the State Govt. to pay the recurring expenses. This scheme was sanctioned in October 1975 and a planned total expenditure of Rs. 3.77 lakhs spread over 2 years was allotted by the Central Govt. Technical assistance is also being provided by the UNDP expert posted in the country. We decided to have one more rehabilitation centre which was located at Katerniaghat near the river Girwa. By June 1976, the construction of 30 hatchling ponds with a capacity for 450 hatchlings and 4 yearling ponds with a capacity for 80 yearlings was completed. Ten of the hatchling ponds were located at Katerniaghat centre. Meanwhile survey efforts were stepped up and between December 75 and May 76, our survey team constantly surveyed the Narayani, Son, Ghaghra, Ramganga and chiefly the river Chambal and Girwa to locate more breeding populations and nesting sites of gharial. The efforts were well rewarded and we were able to locate 9 nests out of which 3 were found on the Girwa and the other 6 on the Chambal. These nests yielded us 342 eggs (215 Girwa and 127 Chambal). The Chambal eggs gave us nearly 95% hatching success while it was 71% in the case of Girwa ones. The number of yearlings surviving now (Aug. 77) out of these are 235, Girwa eggs yielded weak hatchlings which suffered from physical defects and their mortality was high during the course of 12 months. Chambal hatchlings, on the other hand were healthier and sturdy.

It became necessary to increase the number of yearling ponds to accommodate the 235 yearlings against our existing capacity for 80 yearlings only. Accordingly 4 yearling ponds were added to the Kukrail complex and another 4 ponds to the Katerniaghat. This raised the total number of yearling ponds to 8 at Kukrail and 4 at Katerniaghat which among them could provide for at least 240 to 250 yearlings. No hatchling ponds were added as we did not expect to collect more than 400 to 450 eggs during the 1977 summer nesting season.

Efforts were intensified to locate maximum number of eggs both along Chambal and Girwa during the 1977 nesting season. Separate survey parties were deputed to these two rivers with adequate number of boats, transport and men both local and our own staff. They stayed in the area from February onwards till they located all the possible nests. As many as 12 gharial nests were located on the Chambal which yielded 497 eggs. These eggs were brought to Kukrail centre in the last week of May 77. On the Girwa 4 nests were located with 166 eggs. While the eggs from 3 nests were brought to Katerniaghat centre one nest with 30 eggs was left at the site to observe the hatching percentage in nature. The hatching success came to 90 to 94% which yielded 599 hatchlings. The nest which was kept undisturbed on the site at Girwa yielded 30 hatchlings, but 7 died immediately. The twenty three hatchlings were collected and brought to Katerniaghat centre for rearing. We had thus 553 hatchlings from the 1977 eggs. Our existing hatchling ponds, as indicated earlier, have capacity for only 450 hatchlings. We had therefore to resort to relative crowding and had to send 100 Chambal hatchlings from Kukrail to Katerniaghat as a measure of proper distribution of space and work load.

The following table gives the existing stock position of gharial hatchlings and yearlings at our two centres. It also gives consolidated information about the number of nests, and eggs collected during the last three years as also their hatching percentages etc. (see p. 678).

Though this paper deals only with the work done by us about gharial rehabilitation, we also collected mugger (*Crocodylus palustris*) eggs which were found along the Chambal river banks during the course of our survey. We have the following number of muggar hatchlings and yearlings also at our Kukrail centre:

The above figures show that we have in stock 247 gharials which will be big enough to be released in the wild by the end of Fabruary 1978.

Sanctuaries—As mentioned earlier, Girwa river in Bahraich Forest Division has the largest gharial population in the State. A five

Year	egg source	No. of nests	No. of eggs created	No. hatched	% of hatching	No. of surviving of one year age		No. of surviving at 2 years age	
						No·	%	No.	%
1975	Girwa	1	38	21	55.3	12	57	12	100
1976	Girwa	3	215	153	71	42	27.5	–	–
	Chambal	6	217	206	95	193	94	–	–
	Years total	9	432	359	84	235	65	–	–
1977	Girwa	4	166	151	94.5	124			
	Chambal	12	497	448	90	429			
	Years total	16	663	599	91	553			

The following table gives the distribution of surviving gharials to centres:

Egg source	Year of egg collection & hatchling	Currently surviving gharial babies being reared at			Total
		Katerniaghat Centre	Kukrail Centre	Tikarpara Orissa	
Girwa river	1975	–	8	4	12
	1976	19	23	–	42
	1977	124	–	–	124
Chambal river	1976	39	154	–	193
	1977	100	329	–	429
	Total	282	514	4	800

Mugger stock position (Kukrail)

Egg source	Year of egg collection & hatchling	Surviving Juveniles being reared	Remark
Chambal River	1976	2	One wild caught juvenile is also reared.
	1977	33	
	Total	35	

The position of crocodilians at our centre is as follows:

Year of hatchling	Gharial	Mugger
1975	12	–
1976	235	2
1977	553	33
Total	800	35

kilometre stretch of this river has the highest density of gharials in the country. Along with the artificial rearing of gharials and their release in nature, their rehabilltation depends on the protection afforded to the existing population as also to the artificially bred young after their release. It was considered necessary to give higher legal status to the entire eco-system which held the largest surviving population of gharials in the State.

The Girwa river and the forest around this river were the obvious choice and an area covering 400 square kilometres was constituted into a wildlife sanctuary in the year 1976. In addition to the breeding population of gharial this sanctuary contains rich wildlife including Mugger, tiger, panther, swamp deer, blackbuck, chital, hogdeer, blue bull, pigs and variety of birds including red jungle fowl, partridges etc. The first five species listed above are protected animals included under schedule I of the wildlife Protection Act 1972. In addition to the normal territorial and wildlife staff posted in the area one Assistant Wild Life Warden has been posted for the protection of gharials. A scientific management plan is being drawn for this sanctuary which will considerably improve the habitat and environmental conditions in the area after its enforcement.

There is a proposal to create another sanctuary to cover the length of the river Chambal which has a breeding population of gharials or which has suitable habitat where gharials can live and breed. This sanctuary will be spread over the three states of U.P., M.P. and Rajasthan. Government of India has accepted our proposal in this connection and have initiated action for the early creation of this sanctuary.

Corbett National Park is another protected area in the State which has ideal habitat for gharials in the form of river Ramganga. Though this river has at present only 5 gharial adults, it can provide a home for more gharials.

The above three rivers have been selected for the release of gharial young reared at our two centres. The first lot of juveniles will be released in February 1978. They will be intensively protected and looked after. In due course other areas which have suitable stretches of gharial habitat, will be given the status of sanctuaries for the release of captive bred gharials.

This paper will not be complete without details of techniques adopted in each operation involved in the rearing of gharial. The different operations are (i) location of nests (ii) Incubation of eggs (iii) Transfer of eggs to centres (iv) Hatching (v) Rearing enclosures (vi) Feeding and (vii) Protection against winter and diseases etc.

Location of nests: Gharials have been found to be regular nesters and the nesting season does not vary by more than 10 days in any year. Determination of the nesting season in a particular region is vital for nest location. It was interesting to note the nesting by all the 12 females spread over a stretch of nearly 200 kilometres of Chambal which occurred within a period of 7 days. Pre-nesting behavious consists of excavation of trial nests by the females which they start about a month before the actual nesting. The excavation of these trial nests gives vital clues to the location of actual nests. Each female gharial may excavate about a dozen trial nests before laying her eggs in one of these. The location of each trial nest is marked by fixing a peg about 3 metres away from the trial nest in parpendicular direction from the waters edge. This ensures the location of all possible nests. After all nesting activity ceases each trial nest is excavated carefully to check the presence of eggs. If the nest is still not located, the entire nesting area is systematically probed with a 4 mm thick steel road to a depth of about 45 cm. This usually results in the puncturing of a few eggs with the location of every nest but an experienced prober can bring the incidence down to a minimum.

Incubation: Gharials exhibit wonderful nesting habits. Nesting sites are normally so chosen as to give very high incubation success. The incubation medium has the dual quality of allowing good permeability of air as well as proper humidity to meet the moisture requirements of the developing embryos.

This is achieved as a result of balance between the grain size of the sand and its moisture content which varies between 4% to 7% by weight. Furthermore, the eggs are laid at a depth where steady conditions are maintained for the developing embryos. The temperature does not vary much throughout the day neither does the humidity change with the occurrence of rainfall during the incubation months. The range of incubation temperature varies between 25 degrees C (minimum) and 37 degree (maximum) but the range of optimum incubation temperature is considered to lie between 32 degree and 34 degree, which reduces the incubation time and gives better hatching success. In order to reduce the possibilities of mal-effects on embryos from human interference it is most advisable to allow the eggs to remain in the nest for at least 40 days so that partial incubation is achieved and the embryos are not damaged during transport or movement. In no case should the eggs be interfered with within 15 days of their being laid. Some times on account of various reasons females lay eggs in conspicuously bad nesting medium. Such mediums are (i) over moist sand in places susceptible to inundation by the river water (ii) too dry sand (iii) sand grains of too large a size and (iv) sand with high humus content. In such conditions, eggs should be transferred to better locations close by so that the clutch may be saved from decomposition.

A thumb rule for the testing of proper humidity and permeability of the incubation medium is to compress the sand in the hand. The sand should be cohesive enough to form a ball which when pressed lightly with a finger should crumble again.

Transfer of eggs: As indicated in the previous para, the eggs are transferred after incubation has been completed partially. The transfer to the incubation and rearing centres is done in boxes made of wooden planks (about 40 days after they are laid). The boxes are filled with sand from the nesting area as they provide an ideal medium not only for transport but also for incubation.

The boxes should be sturdy and there should be fine slits or holes to allow for the passage of air into the transportation boxes. Several layers of eggs may be transported in one box which should not exceed the size 60 x 45 x 45 cm. Even smaller boxes are preferable.

When the nest is opened for the transfer of eggs, each egg is marked at its highest portion with indelible ink. During removal of the eggs care is taken to retain the original orientation of the eggs as found in the nest. An egg found in horizontal position is removed in the same position and is kept in the box also in the same position. Similarly an upright egg is kept upright without rotation on its axis. The aggs are transferred to the transportation box and kept so that the lowest layer of eggs is separated from the bottom as well as from all the sides of the box by a layer of sand 4 to 6 cm thick. The eggs should be separated from each other also by at least 1.5 cm. The eggs are then transferred as quickly as possible to the incubation centre by the fastest transport available.

The importance of avoiding bumps and jerks cannot be over emphasized. Care should also be taken to eliminate chances of the egg boxes overheating.

At the centre the eggs are transferred into incubation cells built of half bricks such that there are sufficient gaps between the bricks to allow free passage of air. The recommended dimensions of the brick cell are 70 cm cube. The eggs are removed from the boxes and kept in these cells with same precaution as were observed in their transfer from the nest to the box, in single layers after artificial incubating medium has been prepared by mixing together sand with the requisite amount of water. Humidity is controlled until hatching by keeping the bricks wet and by spraying water with an atomizer on the top of the incubation medium.

Hatching: The completion of the incubation is heralded by the croaking of the embryos, signalling their readiness to hatch. After initial croaking is noticed, a time period of 24 to 36 hours should be allowed to lapse before sand is removed from the incubation cells. By this time almost the entire clutch would have started croaking. The hatchlings emerge almost immediately on dehumification and sever their umbilical cord which attaches the egg shell to them, a shortwhile after. When this occurs the egg shell should be removed from the incubation box for purposes of sanitation and hygiene. After a period of about 48 hours the hatchlings are ready for release into the rearing pools.

Rearing enclosures: These are constructed in sets of 10 hatchling ponds, five on either side a central passage. The enclosure containing these ponds has a wall 1 foot high on all four sides and is completely covered by chicken meshwire of ½ inch mesh size. Internal dimension of each pond is 2 metres square. Half of the area has a depth of 45 cm while the other half slopes to zero. Each pond has a 25 cm wide apron on all sides. A space of 80 cm is provided all around the pond in each pond enclosure for the hatchlings to move about and for planting palms, which provide adequate shelter and hiding places for the young.

Yearling ponds are built in sets of 4 ponds, two on either side of a central passage. The enclosure is covered with mesh wire as in the case of hatchling pond enclosures. The size of each pond is 4 metre square and depth one metre, which can ideally accommodate 25 yearlings. The ponds are separated from each other with insect proof mesh supported by sawn timber scantlings and railings. A space of 2 metres is provided between the pond and the partition on all sides.

During the construction of the ponds, arrangements are made by laying under ground pipes with control manholes, both to fill water to the ponds and also to drain them out. Adequate number of palms, *Salix* spp and other suitable shade plants are put in around each pond to provide shade, shelter and hiding space, climbers like *Antigonum* sp. are planted around the enclosures which spread out on all the four sides and also on the mesh wire roof and provide a mosaic of shade and sunlight. This is necessary to keep the water in the ponds cool and temperatures below 30 degree C. This climber should be either a species that sheds its leaves during the winter or should be cut back during the winter to allow the maximum amount of sunlight.

Feeding: Considerable yolk matter is rapidly absorbed through the umbilical cord of the hatchling into its stomach just before hatching. The yolk further maintains the hatchling for a period after its birth. Gradually nutrition from the yolk matter is supplemented with that obtained from feeding. Proper feeding begins after a period of 15-20 days. Hatchlings register a gain in weight after this period but they begin to grow in length noticeably even before.

For feeding hatchling ponds should be ideally stocked with live fingerlings and small fishes between 2.5 mm to 5 mm in length. Each pond which ideally contains 10 hatchlings, should be stocked with atleast 400-500 such fishes to facilitate easy capture of prey by the hatchlings. Rate of feeding increases with the growth of the hatchlings but intially five fishes per hatchling have to be added daily to the ponds to replace those consumed. As it may not be possible to meet the increasing requirements of the live fish, after a critical 2 months post hatching period during which they are delicate in health, feeding should be gradually changed over to dead fish. Dead fishes may be accepted by the hatchlings right from the start but the growth is never as good as when fed on live fish. Decomposing remains of dead fishes also lead to undesirable hygenic conditions. Non-spiny fishes like *Chela* and *Puntius* are most favoured by the hatchlings. The preferred fishes are:—(i) *Puntius ticto* (Putia), (ii) *Chanda ranga* (Chanda), (iii) *Rasobora daniconius,* (iv) *Colisa fasciata,* (v) *Chenna punctatus* (Girai), (vi) *Chenna striatus* (Saur), (vii) *Labeo bata* (Bata).

Other fishes which were locally available in Kukrail river and were given to the hatchlings are:

(i) *Mystus mystus* (Tengra)
(ii) *Labeo rohita* (Rohu)
(iii) *Labeo calbasu* (Kalabose)
(iv) *Heteropneustes fossilis* (Singhi)
(v) *Clarias batrachus* (Mangur)
(vi) *Amphipnous cuchia* (Bam)

Hygiene:

As gharial hatchlings defecate in the water the ponds soon become dirty and have to be scrubbed out every third day to maintain good hygiene in the enclosures. The land surrouding the ponds and the passage ways are also swept out daily. As an efficient and adequate supply of running water is necessary, both the centres have their own arrangements with tube well and pumping sets. Terrapins (*Kachuga tecturn*) are also kept and maintained in the ponds as they are useful scavangers.

Winter Protection: In North India winter temperatures fall as low as 4°C. In the restricted environment of the rearing ponds temperatures fall sharply during the night. Extreme cold not only arrests feeding and growth but may also lead to disease and mortalities. Frequent change of water in the ponds with warm tube well water (temp. 20°C) and covering the enclosures have been found effective in maintaining the pond temperature within a tolerable range of 15°C to 20°C. As maximum amount of sunlight is required for basking during the day, thick transparent polythene is fitted on wooden frames to cover the roof permanently during the period mid-November to mid-February. Heavy overlapping tarpaulin curtains hung on the sides which are rolled up during the day protect the enclosures from cold winds during the night.

Electric room heaters hung about 75 cm above the ponds provide supplementary heating. At least one heater (1000 Watts) per pond is required before these are effective in a large enclosure. Care is however taken to prevent possible overheating and temperature is not allowed to go above 20°C.

Diseases, their prevention and cure:

Most common and dangerous is the mouth

chancre which has been found to be extremely infectious within a particular strain. The symptoms are rotting of the gums and falling of teeth. Patches on the snout become discoloured brown and the animals slowly grow weak due to their inability to feed properly. Diseased animals should be isolated. All articles leaving or entering the pond as well as hands and feet of all concerned staff are disinfected by dipping in 10% solution of potassium permanganate. The importance of strict isolation of diseased animals cannot be over emphasized. The treatment of this disease consists of scraping away the diseased parts with a sterilised knife or scalpel and then swabbring over with 5% solution of Acroflavin. This is done daily until the symptoms disappear. Another ailment is the protrusion of the cloaca which leads to possible difficulty in defecation. Causes or the treatment of this malady is not known but the protrusion may be swabbed over by Acroflavin solution in order to prevent infection of the exposed internal organ. In a few cases intestinal cysts have also resulted in mortality.

Not much information is available about other diseases and their treatment. Intensive study is required in this direction.

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I am most grateful of Sri D. Basu, Surveyor and the staff of the Crocodile Rehabilitation Project (U.P.) who carried out the status survey, who located breeding populations, collected eggs and brought them to the Centres. But for their hard work and devotion to the success of the Project, we could not have made any progress in the implementation of this Project. I am particularly thankful to Basu for assisting and providing field data for this paper.

RARE AND THREATENED FLOWERING PLANTS OF SOUTH INDIA

A. N. Henry, K. Vivekananthan and N. C. Nair[1]

A catalogue of 224 species of flowering plants presumably in danger of extinction in South India is given, based on the information from the distribution of species available in MH and relevant literature. It is hoped that the list, which provides the essential preliminary to any Nature Conservation programme in South India, will be used by the Conservationists to select suitable biotic communities for the preservation of flora and fauna.

The establishment of various international bodies, like International Union for Conservation of Nature and Natural Resources, have initiated programmes for rational and prudent approach to the exploitation of natural resources and conservation of biotic communities by considering the status of rare and threatened species of plants and animals and their habitats. Tinker (1971) reports that "twenty thousand plant species—in danger of extinction. The essential preliminary to any conservation programme is a precise catalogue of what these species are, but so far only 68 are listed in IUCN's Red Data Book."

About 14,000 species of wild flowering plants have been reported in India, and the great mountain chains of Himalayas, Western Ghats, Vindhya and Satpura ranges, Eastern Ghats, Khasi and Mizo Hills harbour about 90% of them. Due to indiscriminate encroachment of forest areas for agriculture, plantation crops and hydro-electric projects, the "refugia" for the wild species have been disturbed, and these no doubt pose a threat to the very existence of the comparatively rare/endemic local plants which illustrate definite evolutionary processes and potentialities. As correctly pointed out by Subramanyam & Nayar (1971) "there is no alternative to natural habitats in the propagation of rare plants, though botanic gardens and seed banks are the only temporary answers to the solution of Conservation".

In the Enumeration, 224 wild species of flowering plants presumably in danger of extinction in South India are listed, based on the information for the distribution of species available in MH and relevant literature. For each species the type locality including the maximum known range of distribution and habitats (if available) is given, followed by remarks, if any, on its probable present status. For easy reference, the species are grouped under their respective families following the classification of Bentham and Hooker, with present day delimitation of certain families. The list is by no means complete, and further additions will be published in subsequent series. It is our sincere hope that the list, which provides the essential preliminary to any Nature Conservation programme in South India, will be used by the Conservationists to select suitable biotic communities for the preservation of flora and fauna.

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[1] Botanical Survey of India, Southern Circle, Coimbatore-641 002.

ENUMERATION

ANNONACEAE

Desmos viridiflorus (Bedd.) Safford
Unona viridiflora Bedd.
Banks of Sholayar river, Anamalais, Coimbatore Dt., Tamil Nadu; Udumanparai, Anamalais.
Scarce.

Polyalthia rufescens Hook. f. & Thoms.
Cochin in Ernakulam Dt., Kerala; Travancore; Tirunelveli hills, Tamil Nadu.
Scarce.

Popowia beddomeana Hook. f. & Thoms.
Southern Tirunelveli Dt., Tamil Nadu and Southern Travancore, in evergreen forests; Attraymallay in Trivandrum Dt., Kerala.
Scarce.
Located in the evergreen forests of Agastyamalai in Tirunelveli Dt., Tamil Nadu in 1963.

VIOLACEAE

Hybanthus travancoricus (Bedd.) Melch.
Ionidium travancoricum Bedd.
Hills of Tirunelveli, Tamil Nadu and Travancore.
Located along streams in Agastyamalai in Tirunelveli Dt., Tamil Nadu in 1963.

HYPERICACEAE

Hypericum japonicum Thunb. var. **major** Fyson
Nilgiris on western downs, Tamil Nadu.
Rare. No specimens in MH.

GUTTIFERAE

Garcinia imberti Bourd.
Southern Travancore—in evergreen forests.
No specimens in MH.

DIPTEROCARPACEAE

Vateria macrocarpa B. L. Gupta
Muthukulam, Bolampatty range, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

MALVACEAE

Decaschistia rufa Craib
Tiruvallur and Kambakkam hills in Chingleput Dt., Tamil Nadu and from the 'Peninsula' (without precise locality).
No specimens in MH.

ELAEOCARPACEAE

Elaeocarpus venustus Bedd.
Muthukuzhivayal, Kanyakumari Dt., Tamil Nadu; Chimunji, S. Travancore.
Scarce and little known.
Located in the type locality in evergreen forests in 1976-1977.

BALSAMINACEAE

Impatiens aliciae C. E. C. Fischer
Travancore; Munnar—Neriamangalam ghat road, Idikki Dt., Kerala—along streams.
No specimens in MH.

I. anaimudica C. E. C. Fischer
Anaimudi, Idikki Dt., Kerala—in dense undergrowth in sholas.
No specimens in MH.

I. cochinica Hook. f.
Kavalay, Cochin, Ernakulam Dt., Kerala—near streams.
No specimens in MH.

I. coelotropis C. E. C. Fischer
Naimakad gap & Anaimudi slopes, High range, Idikki Dt., Kerala—in sholas and evergreen forests.
Located in the type locality during 1965.

I. concinna Hook. f.
W. Ghats in Malabar, Kerala (precise locality not known).
No specimens in MH.

I. dendricola C. E. C. Fischer
Thandiadamolu, Coorg, Karnataka.
No specimens in MH.

I. johnii Barnes
Kalaar Valley, High Range, Idikki Dt., Kerala—in dense evergreen forest.
No specimens in MH.

I. laticornis C. E. C. Fischer
Kundahs, Nilgiris, Tamil Nadu—on wet rocks in deep shade.
Not located since the type collection.

I. macrocarpa Hook. f.
Devicolam in Idikki Dt., Kerala.
No specimens in MH.

I. munnarensis Barnes
Near Munnar, High Range, Idikki Dt., Kerala—in streams and marshy places.
No specimens in MH.

I. nataliae Hook. f.
Kumsi in Shimoga in N.W. Mysore, Karnataka.
No specimens in MH.

I. neo-barnesii C. E. C. Fischer
Kundahs, Nilgiris, Tamil Nadu—on trunks & branches of trees exposed to much rain and mist from Malabar.
Located in Nilgiri Peak R.F., Kundahs, during 1970.

I. nilgirica C. E. C. Fischer
Kundahs, Nilgiris, Tamil Nadu—among grass and on rocks.
Not located since the type collection.

I. pallidiflora Hook. f.
Devicolam in Idikki Dt., Kerala—among grass on hill tops.
Located from Periakanal and Santanpara areas in Devicolam, Idikki Dt., Kerala by E. Barnes during 1931-37.
No specimens in MH.

I. pandata Barnes
Anaimudi slopes, Idikki Dt., Kerala—on wet rocks in tufts of moss and on cliffs at high elevation; Karankulam, Idikki Dt., Kerala.
Located in the type locality during 1967.

I. platyadena C. E. C. Fischer
Anaimudi, Idikki Dt., Kerala; Naimakad gap & Kadalaar, High Range, Idikki Dt., Kerala—in evergreen forest and wet sholas.
No specimens in MH.

I. rivulicola Hook. f.
Puriar Valley, Travancore—along the borders of streams.
Located in and near Munnar, Lockhart gap, Periakanal in Idikki Dt., Kerala along streams and rocky slopes by E. Barnes during 1931-37.
No specimens in MH.

I. stocksii Hook. f.
Thandiandamolu, Coorg, Karnataka.
No specimens in MH.

I. verecunda Hook. f.
Periakanal and Devicolam, Idikki Dt., Kerala—on steep mossy embankments under trees.
No specimens in MH.

BURSERACEAE

Boswellia ovalifoliolata Balak. & Henry
Tirupathi Hills, Chittor Dt., & Nallamalai, Kurnool Dt., Andhra Pradesh.

MELIACEAE

Aglaia canarensis Gamble
W. Ghats of S. Kanara, Karnataka.
Not located since the type collection.

A. maiae Bourd.
Ariyaukam and Colatoorpolay in Travancore,—in evergreen forests.
No specimens in MH.

AQUIFOLIACEAE

Ilex gardneriana Wt.
Sispara Ghat in Nilgiris, Tamil Nadu.
Scarce. No specimens in MH.

CELASTRACEAE

Microtropis densiflora Wt.
Below Sispara at Nilgiris, Tamil Nadu—in dense jungles.
Scarce. Located in Pykara, Nilgiris during 1971.

HIPPOCRATEACEAE

Loeseneriella bourdillonii (Gamble) Raju
Hippocratea bourdillonii Gamble
Colatoorpolay, Travancore—in evergreen forests.
No specimens in MH.

Salacia beddomei Gamble
Anamalai hills of Coimbatore Dt., Tamil Nadu; Wynaad.
Not located since the type collection.

S. malabarica Gamble
S. Kanara, Karnataka and Travancore—in plains and in moist forests.
Not located since the type collection.

RHAMNACEAE

Ventilago goughii Gamble
Coorg, and Coonoor ghat, Nilgiri Dt., Tamil Nadu; Segur ghat, Nilgiris.
Located in Kunjapanai, Nilgiris and Thirukarungudi in Tirunelveli Dt., Tamil Nadu during 1972.

ANACARDIACEAE

Buchanania barberi Gamble
Nadarai in Travancore.
Not located since the type collection.

Nothopegia aureo-fulva Bedd. ex Hook. f.
Hills above Courtallam, Tirunelveli Dt., Tamil Nadu.
Not located since the type collection.

CONNARACEAE

Ellipanthus neglectus Gamble
Tirunelveli, Tamil Nadu and Colatoorpolay, Travancore—in evergreen forests.
Not located since the type collection.

PAPILIONACEAE

Indigofera constricta (Thw.) Trimen
Ceylon; Kavalay, Cochin, Ernakulam Dt., Kerala, Nikund ghat, N. Kanara, Karnataka.
Rare. Located in Ranni R. F., Quilon Dt., Kerala during 1976.

Rhynchosia jacobii Chandr. & Shetty
Thulukkanparai—eastern slope of Mahendragiri hills, Tirunelveli Dt., Tamil Nadu.

Smithia venkobarowii Gamble
Peermade, Idikki Dt., Kerala.
No specimens in MH.

CAESALPINIACEAE

Cynometra mimosoides Wall.
W. Ghats in S. Travancore; Cannanore.
Apparently very scarce.

Humboldtia laurifolia Vahl
Ceylon & W. Ghats in Malabar.
Apparently very scarce.
One collection (without locality) available in MH collected during 1873.

MIMOSACEAE

Acacia hohenackeri Craib
Kundah range, Nilgiris, Tamil Nadu.
Located in Bimka Shola, Nilgiris, Tamil Nadu in 1970.

A. wightii Baker
Travancore, and Tirunelveli, Tamil Nadu—on the sea coast.
No specimens in MH.

MYRTACEAE

Eugenia discifera Gamble
Near Chimunji, Travancore—in evergreen forests.
No specimens in MH.

Jambosa beddomei (Duthie) Gamble
Trichnangudi, Tirunelveli hills, Tamil Nadu.
No specimens in MH.

J. bourdillonii Gamble
Merchiston, Ponmudi hill, Trivandrum Dt.—in evergreen forests.
Not located since the type collection.

J. courtallensis Gamble
Courtallum, Tirunelveli Dt., Tamil Nadu & Ceylon.
No specimens in MH.

Meteoromyrtus wynaadensis (Bedd.) Gamble
Devala (Nilgiris, Tamil Nadu) South East Wynaad.
No specimens in MH.

Syzygium benthamianum (Wt. ex Duthie) Gamble
Sispara in Nilgiri hills, Tamil Nadu.
No specimens in MH.

S. palghatense Gamble
Palghat hills, Kerala.
No specimens in MH.

S. travancoricum Gamble
Low Country of Travancore—in swampy places.
Not located since type collection.

MELASTOMATACEAE

Kendrickia walkeri Hook. f.
Anamalai hills, Coimbatore Dt., Tamil Nadu. Ceylon.
Reported from Peninsular India based on a single collection from Anamalai.
No specimens (from South India) in MH.

Memecylon flavescens Gamble
Avalanche and Sispara, Kundahs, Nilgiris, Tamil Nadu—in evergreen shola forests.
Located in shola forests in the type locality in 1972.

M. lawsoni Gamble
South East Wynaad; Devala, Nilgiris, Tamil Nadu.
Collections from the type locality, available in MH.

M. madgolense Gamble
Madgol hills of Visakhapatnam Dt., Andhra Pradesh.
No specimens in MH.

M. sisparense Gamble
Sispara ghat, Nilgiri hills, Tamil Nadu.
Collection from the type locality available in MH.

Sonerila barnesii C. E. C. Fischer
Nadugani, Tirunelveli hills, Tamil Nadu.
No specimens in MH.

S. nemakadensis C. E. C. Fischer
Naimakad gap, High range, Idikki Dt., Kerala.
No specimens in MH.

S. pulneyensis Gamble
Pambar ravine, Pulney hills, Madurai Dt., Tamil Nadu.
Subsequent collection from the type locality made during 1901 available in MH.

S. wynaadensis Nayar
Wynaad, Kerala.
Not located since the type collection.

LYTHRACEAE

Lagerstroemia rottleri Clarke
Deccan (exact locality not known).
Little known tree. No specimens in MH.

L. thomsonii Koehne
Mysore and Carnatic; probably W. Ghats.
Apparently very rare. No specimens in MH.

CUCURBITACEAE

Luffa umbellata (Klein) Roem.
Travancore, Kerala; Coromandel—(precise locality not known).
Scarce. A single collection without precise locality is available in MH.

UMBELLIFERAE

Peucedanum anamallayense Clarke
Anamalai hills, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

Pimpinellla pulneyensis Gamble
Near shola, Kodaikanal, Madurai Dt., Tamil Nadu—in damp and cool places near sholas.
Not located since the type collections.

P. tirupatiensis Balak. & Subr.
Japalathirtha, Tirupati hills, Chittoor Dt., Andhra Pradesh.
Subsequently collected from the type locality during 1974.

ARALIACEAE

Schefflera bourdillonii Gamble
Near Chimunji, Travancore, Kerala—in evergreen forests.
No specimens in MH.

RUBIACEAE

Coffea crassifolia Gamble
Ayerpadi, Anamalais, Coimbatore Dt., Tamil Nadu & Peermade, Idikki Dt., Kerala.
Not located since the type collection.

Hedyotis anamalayana (Gamble) Rolla Rao & Hemadri
Oldenlandia anamalayana Gamble
Anamalai hills in high ranges, Coimbatore Dt., Tamil Nadu.
Not located since the type collection.

H. barberi (Gamble) Henry & Subr.
Oldenlandia barberi Gamble
Agastyamalai peak, Tirunelveli Dt., Tamil Nadu—in rocky places.
Located in the type locality in 1964.

H. beddomei Hook. f.
Oldenlandia beddomei (Hook. f.) O. Ktze.
Palghat hills, Kerala—in open grassy places.
Collection from the type locality available in MH.

H. bourdillonii (Gamble) Rolla Rao & Hemadri
Oldenlandia bourdillonii Gamble
Travancore—in scrub forests.
No specimens in MH.

H. gamblei Henry & Subr.
Manjanamparai, Tirunelveli Dt., Tamil Nadu.

H. ramarowii (Gamble) Rolla Rao & Hemadri
Oldenlandia ramarowii Gamble
Ponmudi, Trivandrum Dt., Kerala; Chimunji, Travancore; Kalakad, Tirunelveli Dt., Tamil Nadu.

H. santapaui Shetty & Vivek.
Umaiyamalai, Anaimudi slopes, Devicolam, Idikki Dt., Kerala and Anamalais, Coimbatore Dt., Tamil Nadu; subsequently collected from the type locality.

H. shuteri (Hook. f.) Rolla Rao & Hemadri
Oldenlandia shuteri Hook. f.
Near Madras—east coast, Tamil Nadu.
No specimens in MH.

H. stocksii (Hook. f. & Thoms.) Rolla Rao & Hemadri
Oldenlandia stocksii Hook. f. & Thoms.
Bababudan hills of Mysore (Malabar), Karnataka—Growing among grass.
Not located since the type collection.

H. travancorica Bedd.
Oldenlandia travancorica (Bedd.) O. Ktze.
Hills of Travancore, and Tirunelveli, Tamil

Nadu—in humus soil; Trivandrum, Kerala.
Located in Agastyamalai, Tirunelveli Dt., Tamil Nadu during 1963 & 1964.

H. villostipulata (Gamble) Rolla Rao & Hemadri
Oldenlandia villostipulata Gamble
Muthukuzhivayal, Kanyakumari Dt., Tamil Nadu.
Not located since the type collections.

H. wynaadensis (Gamble) Rolla Rao & Hemadri
Oldenlandia wynaadensis Gamble
Chambra peak forests, Wynaad, Kerala.
Not located since the type collections.

Ixora johnsoni Hook. f.
Near Wenna Mala in Cochin. Ernakulam Dt., Kerala; Travancore, Kerala.
Apparently scarce. No specimens in MH.

I. lawsoni Gamble
Mananthody, Cannanore Dt., Kerala & Coorg, Karnataka.
Not located since the type collection.

I. monticola Gamble
High Wavy mountain near Cumbum, Madurai Dt., Tamil Nadu—in clayey soil.
Located from Sultan's Battery, Calicut Dt. and Karapara river side in Palghat Dt., Kerala during 1969 & 1975 respectively.

I. saulierei Gamble
Pulney hills, Madurai Dt., Tamil Nadu.
Not located since the type collection.

Knoxia linearis Gamble
Mahendragiri hills, Tirunelveli Dt., Tamil Nadu.
Not located since the type collection.

Morinda reticulata Gamble
Murchison and Kulathurpolay, Travancore, Kerala—in evergreen forest.
Not located since the type collection.

Ophiorrhiza barnesii C.E.C. Fischer
Kalaar Valley, High Range, Idikki Dt., Kerala.
No specimens in MH.

O. caudata C.E.C. Fischer
Kalaar, High Range, Idikki Dt., Kerala—in evergreen forests.
No specimens in MH.

O. incarnata C.E.C. Fischer
Near Nadgani, Nilgiri Dt., Tamil Nadu (Wynaad)—in Pandanus swamp.
No specimens in MH.

O. munnarensis C.E.C. Fischer
Munnar ghat road, High Range, Idikki Dt., Kerala.
No specimens in MH.

O. pykarensis Gamble
Pykara falls, Nilgiris, Tamil Nadu.
Not located since the type collection.

Plectronia pergracilis (Bourd.) Gamble
Colatoorpolay, Travancore,—in evergreen forests.
Not located since the type collection.

Psychotria barberi Gamble
Udubanparai, Anamalai Hills, Coimbatore Dt., Tamil Nadu & Pisga Camp, near Munnar, Idikki Dt., Kerala.
Not located since the type collection.

P. globicephala Gamble
Courtallam, Tirunelveli Dt., Tamil Nadu.
Not located since the type collection.

COMPOSITAE

Anaphalis barnesii C.E.C. Fischer
High Ranges, Idikki Dt., Kerala.
No specimens in MH.

Centrantherum mayurii C.E.C. Fischer
Kemmangundi hills, Mysore, Karnataka.
No specimens in MH.

Helichrysum perlanigerum Gamble
Anamalai hills, at higher elevations, Coimbatore Dt., Tamil Nadu.
Not located since the type collections.

Vernonia anaimudica Shetty & Vivek.
Rajamallay,—Anaimudi slopes, Devicolam,

Idikki Dt., Kerala.

V. anamallica Bedd. ex Gamble
Anamalai higher ranges, Coimbatore Dt., Tamil Nadu.
Located from Pettimudi, Devicolam, Idikki Dt., Kerala during 1965 & 1970.

V. gossypina Gamble
Between Naterikal and Sengaltheri, Tirunelveli Dt., Tamil Nadu.
Located from Singampatti, Tirunelveli Dt., in 1958.

V. heynii Bedd. ex Gamble
Travancore hills in Kerala.
Located from Mahendragiri hills, Kanyakumari Dt., Tamil Nadu in 1969.

V. membranacea Bedd. ex S. Moore
Sispara, Nilgiris, Tamil Nadu & Attraimalais, Trivandrum Dt., Kerala.
No specimens in MH.

V. multibracteata Gamble
Peermade, Idikki Dt., Kerala.
No specimens in MH.

V. pulneyensis Gamble
Banks of Pambar river at Kodaikanal, Madurai Dt., Tamil Nadu.
No specimens in MH.

V. recurva Bedd. ex S. Moore
Anamalais, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

V. shevaroyensis Gamble
Shevaroy hills, Salem Dt., Tamil Nadu.
Located in the type locality in 1966.

Senecio kundaicus C.E.C. Fischer
Kundahs, Nilgiri hills, Tamil Nadu.
No specimens in MH.

S. mayurii C.E.C. Fischer
Kemmangandi hills, Mysore, Karnataka.
No specimens in MH.

Youngia nilgiriensis Babcock
Sispara, Nilgiri Dt., Tamil Nadu.
No specimens in MH.

SYMPLOCACEAE

Symplocos candolleana Brand
Anamalais, Coimbatore Dt., Tamil Nadu; Coorg, Karnataka.
Very little known. No specimens in MH.

OLEACEAE

Jasminum wightii Clarke
Boluvampatty, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

ASCLEPIADACEAE

Brachystelma bourneae Gamble
Pulney hills, Madurai Dt., Tamil Nadu—at low levels in eastern slopes.
No specimens in MH.

B. brevitubulatum (Bedd.) Gamble
Vellore, North Arcot Dt., Tamil Nadu—dry rocky hills.
No specimens in MH.

B. glabrum Hook. f.
Hills of Cuddapah, Andhra Pradesh.
No specimens in MH.

B. rangacharii Gamble
Hassanur, Mysore, Karnataka.
Not located since the type collection.

B. volubile Hook. f.
Cuddapah hills, Andhra Pradesh.
No specimens in MH.

Caralluma diffusa (Wt.) N.E. Br.
Coimbatore, Tamil Nadu—arid rocky hills.
No specimens in MH.

C. nilagiriana Kumari & Subba Rao
Anaikatty to Ebanad, Nilgiri Dt., Tamil Nadu.

Ceropegia beddomei Hook. f.
Peermade, Idikki Dt., Cochin, Ernakulam Dt., Kerala.
Located from Pachakkanam in Idikki Dt., during 1975.

C. brevicollis Hook. f.
Anamalai hills, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

Marsdenia tirunelvelica Henry & Subr.
Agastyamalai hills, Tirunelveli Dt., Tamil Nadu.

Oianthus beddomei Hook. f.
Beigoor forests, Mysore, Karnataka & (Wynaad).
No specimens in MH.

Streptocaulon kleinii Wt. & Arn.
Deccan Peninsula (exact locality not known).
No specimens in MH.

Toxocarpus beddomei Gamble
Attraimalai hills, Tirunelveli Dt., Tamil Nadu.
Not located since the type collections.

Tylophora zeylanica Decne.
Ceylon; Travancore.
No specimens in MH.

BORAGINACEAE

Cordia diffusa Jacob
Nanjundapuram, Coimbatore Dt., Tamil Nadu; in and around Coimbatore town.

Tournefortia wightii Clarke
Deccan Peninsula (exact locality not known), probably Anamalai hills, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

CONVOLVULACEAE

Argyreia arakuensis Balak.
Araku Valley, Visakhapatnam Dt., Andhra Pradesh—near a stream.

GESNERIACEAE

Didymocarpus lyrata Wt.
Courtallam, Tirunelveli Hills, Tamil Nadu, —in moist shady places.
No specimens in MH.

D. macrostachya Barnes
Ottaparai Ridge, High Range, Idikki Dt., Kerala.
No specimens in MH.

D. wightii Gamble
Sivagiri Hills in Tirunelveli Dt.; Anamalai Hills, Coimbatore Dt., Tamil Nadu.
Apparently very rare. No specimens in MH.

OROBANCHACEAE

Christisonia saulierei Dunn
Kodaikanal, Madurai Dt., Tamil Nadu.
No specimens in MH.

SCROPHULARIACEAE

Adenosma malabaricum Hook. f.
Malabar, Kerala.
No specimens in MH.

ACANTHACEAE

Adhatoda beddomei Clarke
S. Travancore.
Located from Sengumal Estate (Near Panagudi), Kanyakumari Dt., Tamil Nadu in 1972.

Andrographis beddomei Clarke
Nallamalais, Kurnool District; Lankamalai hills, Cuddapah Dt., Andhra Pradesh.
No specimens in MH.

A. nallamalayana Ellis
Ahobilam, Nallamalais, Kurnool Dt., Andhra Pradesh.
Subsequently collected in and around the type locality.

Dicliptera beddomei Clarke
Nallamalais, Kurnool Dt., Andhra Pradesh.
No specimens in MH.

Nilgirianthus circarensis (Gamble) Brem.
Strobilanthes circarensis Gamble

Hills of Visakhapatnam, Andhra Pradesh.
No specimens in MH.

Rostellularia simplex Wt.
Justicia notha Clarke
"Station not known"; subsequently collected along exposed dry grassy slopes, Kuthiraivetti, Singampatti, R.F., Tirunelveli Dt., Tamil Nadu in 1963.

Santapaua madurensis Balak. & Subr.
Nallakulam, Alagar hills, Madurai Dt., Tamil Nadu.

Stenosiphonium diandrum Wt.
Courtallam in Tirunelveli Dt., Tamil Nadu.
No specimens in MH.

S. setosum T. And.
Mysore or Carnatic.
No specimens in MH.

Strobilanthes dupeni Bedd. ex Clarke
Top of Nelliampathy Ghat, Palghat Dt., Kerala.
No specimens in MH.

VERBENACEAE

Premna glaberrima Wt.
Courtallam, Tirunelveli Dt., Tamil Nadu; Coorg, Karnataka.
Located in Mukkali Forest (Red gravelly soil) in Palghat Dt., Kerala in 1966.

P. paucinervis (Clarke) Gamble
Anamalais, Coimbatore Dt., Tamil Nadu.
A very little known species.
No specimens in MH.

P. procumbens Moon
Ceylon, Mundanthorai in Papanasam R. F. of Tirunelveli Dt., Tamil Nadu.
No specimens in MH.

LABIATAE

Acrocephalus palniensis Muker.
Upper Pulneys, Madurai Dt., Tamil Nadu.
No specimens in MH.

Dysophylla rugosa Hook. f.
Tirunelveli Hills, Tamil Nadu.
No specimens in MH.

Leucas mukerjiana Subba Rao & Kumari
Cherukonda, Visakhapatnam Dt., Andhra Pradesh; subsequently collected from the type locality and Galikonda (Araku Valley side) in Visakhapatnam Dt.

Plectranthus bourneae Gamble
Pulney Hills (near Kodaikanal), Madurai Dt. and near Coonoor, Nilgiri Hills, Tamil Nadu—along streams especially in rocky places.
No specimens in MH.

P. fruticosus Hook. f.
Pulney hills, Madurai Dt., Nilgiris, and Anamalais, Coimbatore Dt., Tamil Nadu—along banks of lakes and streams.
No collections in MH.

P. lushopianus Gamble
Pulney hills at Kodaikanal, Mudurai Dt., Tamil Nadu—in shola forests.
No specimens in MH.

P. rivularis Wt. ex Hook. f.
Sispara in Nilgiris, and Anamalai Hills, Coimbatore Dt., Tamil Nadu — in wet places; Atraimalai Hills, Kerala.
No specimens in MH.

P. subincisus Benth.
Courtallam, Tirunelveli Dt., Dindigul, Madurai Dt., and Ceylon. Scarce.
No specimens in MH.

Pogostemon nilagiricus Gamble
Nilgiris, Tamil Nadu—outskirts of woods and in neglected broken ground.
No specimens in MH.

P. rotundatus Benth.
Deccan Peninsula (exact locality not known); Anamalais in Coimbatore Dt., Tamil Nadu.
No specimens in MH.

PODOSTEMACEAE

Hydrobryum johnsonii (Wt.) Willis
Malabar—in mountain streams.
No specimens in MH.

ARISTOLOCHIACEAE

Apama barberi Gamble
Kannikatti, Tirunelveli Dt., Tamil Nadu.
Located in evergreen forests of Agastyamalai, Tirunelveli Dt., during 1963.

PIPERACEAE

Piper barberi Gamble
Kannikatti, Tirunelveli Dt., Tamil Nadu.
A little known species. Located in the evergreen forests of Agastyamalai in Tirunelveli Dt., and Kilaviarumalai, Balamore in Kanyakumari Dt., Tamil Nadu during 1963 & 1976.

LAURACEAE

Cinnamomum gracile Hook. f.
Tirunelveli Hills and Anamalai hills, Coimbatore Dt., Tamil Nadu; Travancore.
Located in Agastyamalai, Tirunelveli Dt., Tamil Nadu in 1963.

C. riparium Gamble
Banks of Periyar river near Malayattur, Ernakulam Dt., foot of Coorg ghats, Karnataka, and Udubanparai, Anamalai in Coimbatore Dt., Tamil Nadu.
Not located since the type collections.

C. travancoricum Gamble
Chimunji, Travancore (Kerala) in evergreen forests.
Not located since the type collection.

Litsea mysorensis Gamble
Bisli ghat and Aglatti, Karnataka; Wynaad in Kerala.
No specimens in MH.

EUPHORBIACEAE

Aporusa fusiformis Thw.
Ceylon; Travancore hills.
Rather less so in Madras. Recently collected from Anaimudi, Idikki Dt., Kerala in 1966.

Euphorbia santapaui Henry
Agastyamalai hills, Tirunelveli Dt., Tamil Nadu.

Macaranga flexuosa Wt.
Courtallam, Tirunelveli Dt., Tamil Nadu.
No specimens in MH.

Phyllanthus narayanaswami Gamble
Rampa Hills, Godavari, Andhra Pradesh.
Located in Cherukonda, Visakhapatnam Dt., Andhra Pradesh in 1966.

Reidia beddomei Gamble
Chokampatti hills, Tirunelveli Dt., Tamil Nadu, and hills of Travancore.
No specimens in MH.

R. gageana Gamble
South Tirunelveli, Tamil Nadu, and Colatoorpolay, Kerala.
No specimens in MH.

R. megacarpa Gamble
Devala, Nilgiris, Tamil Nadu.
Not located since the type collection.

R. singampattiana Seb. & Henry
Kakachi, Singampatti R.F., Tirunelveli Dt., Tamil Nadu.

R. stipulacea Gamble
Anamalai, Coimbatore Dt., along edge of Pambar stream in thick undergrowth, Pulney hills, Madurai Dt., Tamil Nadu.
Not located since the type collection.

URTICACEAE

Debregeasia ceylanica Hook. f.
Ceylon; Anamalai Hills of Coimbatore Dt., Tamil Nadu; Hills of Travancore, Kerala.
Little known in South India.
Located in Pambanar, Velara-Near Neriyamangalam, Idikki Dt., Kerala in 1965.

BURMANNIACEAE

Haplothismia exannulata Airy Shaw
Parambikulam, Trichur Dt., Kerala (Travancore—Cochin State).
No specimens in MH.

ORCHIDACEAE

Acampe congesta Lindl.
Malabar, Kerala; Ceylon.
No specimens in MH.

Anoectochilus rotundifolius (Blatter) Balak.
Odontochilus rotundifolius Blatter
High wavy Mountains, Madurai Dt., Tamil Nadu—in evergreen forests.
No specimens in MH.

Bulbophyllum mysorense J. J. Smith
Hills of Mysore, Karnataka.
Apparently scarce.
No specimens in MH.

Chilochista pusilla (Willd.) Schlecht.
Cochin, Ernakulam Dt., Kerala. Nilgiris, Tamil Nadu; Ceylon.
Located recently in Ponmudi, Trivandrum Dt., and Peermade in Idikki Dt., Kerala.

Chrysoglossum halbergii Blatter
High Wavy Mountains, Madurai Dt., Tamil Nadu.
No specimens in MH.

Cirrhopetalum acutiflorum Hook. f.
Nilgiris, Tamil Nadu.
Apparently scarce. No specimens in MH.

C. aureum Hook. f.
Wynaad, Kerala.
No specimens in MH.

C. elegantulum (Rolfe.) J. J. Smith
Coorg, Karnataka.
Located in Kudini, Nilgiris, Tamil Nadu during 1972.

Coelogyne mossiae Rolfe
Nilgiri hills; Pulney hills, Madurai Dt., Tamil Nadu—epiphyte or lithophyte.
Located in Rajamalay, Idikki Dt., Kerala in 1970.

Dendrobium haemoglossum Thw.
Ceylon; Wynaad.
Rare.
Located in Sultan's Battery, Calicut Dt., and Thekkady, Idikki Dt., Kerala during 1964 & 1972 respectively.

Eria pseudoclavicaulis Blatter
High Wavy Mountains, Madurai Dt., Tamil Nadu.
No specimens in MH.

Eulophia macrostachya Lindl.
Courtallam, Tirunelveli Dt., and Nilgiris, Tamil Nadu; Ceylon.

Habenaria denticulata Reichb. f.
Tamil Nadu in 1974.

Habenaria denticulata Reichb. f.
Nilgiri Hills, Tamil Nadu.
Very rare.
No specimens in MH.

H. flabelliformis Summerh.
Anaimudi slopes, Idikki Dt., Kerala.
No specimens in MH.

H. polyodon Hook. f.
H. fimbriata Wt.
Nilgiris, Tamil Nadu.
No specimens in MH.

Liparis biloba Wt.
Nilgiri hills, Tamil Nadu.
Located in Kollimund, Kundah range, Nilgiris during 1972.

Paphiopedilum druryi (Bedd.) Pfitz.
Kalakad Hills and Agastyamalai in Tirunelveli Dt., Tamil Nadu.
Recently reported to be collected from Agastyamalai hills.
No specimens in MH.

Peristylus brachyphyllus A. Rich.
Bababudan Hills in Karnataka and Nilgiri Hills in Tamil Nadu.
Located in grassland from Lakkadi—Kun-

dahs, Nilgiris, Tamil Nadu during 1972.

Proteroceras holttumii Joseph & Vajravelu
Eastern slope of Vellingiri hills, Coimbatore Dt., Tamil Nadu—epiphyte on moss clad branchlets of trees of the evergreen shola forests.

Taeniophyllum scaberulum Hook. f.
Kottayam, Kerala.
Very rare.
No specimens in MH.

Vanda wightii Reichb. f.
Nilgiri hills, Tamil Nadu.
Very rare. No specimens in MH.

Vanilla wightiana Lindl.
"Deccan Peninsula"—Travancore, Kerala.
No specimens in MH.

ZINGIBERACEAE

Amomum hypoleucum Thw.
Ceylon; Anamalai hills, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

DIOSCOREACEAE

Dioscorea wightii Hook. f.
Courtallam; hills in Tirunelveli Dt., Tamil Nadu.
Located in the evergreen forests of Agastyamalai hills in Tirunelveli Dt., Tamil Nadu, during 1963.

PANDANACEAE

Pandanus canaranus Warb.
Near Mangalore, Karnataka.
Little is known of this plant.
No collections in MH.

ARACEAE

Arisaema attenuatum Barnes & C.E.C. Fischer
High ranges near Munnar, Idikki Dt., Kerala—in evergreen forests and shady grassy places.
No specimens in MH.

A. auriculata Barnes
Nilambur ghat, Malappuram Dt., Wynaad, Kerala.
No specimens in MH.

A. peltatum C. E. C. Fischer
Near Munnar, Naimakad, Pallivasal, High Ranges, Idikki Dt., Kerala.
No specimens in MH.

A. psittiacus Barnes
Chunduvurrai and Mannavan Shola, High Ranges, Idikki Dt., Kerala.
Specimens from type locality available in MH.

Theriophonum sivaganganum (Ramam. & Seb.) Bogner
Esani forest, Sivaganga, Tamil Nadu.

CYPERACEAE

Ascopholis gamblei C.E.C. Fischer
Ooty, Nilgiris, Tamil Nadu.
No specimens in MH.

Fimbristylis aggregata C.E.C. Fischer
Anamalai Hills, Coimbatore Dt., Tamil Nadu.
No specimens in MH.

GRAMINEAE

Agrostis schmidii (Hook. f.) Bor
Calamagrostis schmidii Hook. f.
Nilgiri Hills, Tamil Nadu.
No specimens in MH.

Chrysopogon velutinus (Hook. f.) Bor
Andropogon velutinus Hook. f.
Cuddapah, Andhra Pradesh.
No specimens in MH.

Cymbopogon travancoriensis Bor
Courtallam, Tirunelveli Dt., Tamil Nadu.
No specimens in MH.

Dichanthium pallidum (Hook. f.) Stapf ex C. E. C. Fischer
Fisch.
Nilgiri hills, Tamil Nadu.
No specimens in MH.

Dimeria bialata C.E.C. Fischer
Siradi, S. Kanara Dt., Karnataka.
No specimens in MH.

Eragrostis rottleri Stapf
Tranquebar, Tanjore Dt., Tamil Nadu.
Little is known of this grass which has not been collected for well over 100 years (Bor).
No specimens in MH.

Heteropogon polystachyos (Roxb.) Schult.
Andropogon polystachyos Roxb.
Deccan (precise locality not known).
A very obscure species.
No specimens in MH.

Isachne decanensis Bor
Ootacamund, Nilgiris, Tamil Nadu — in downs.
No specimens in MH.

I. fischeri Bor
Anaimudi, Idikki Dt., Kerala—along grassy slopes.
Recently located in the type locality in 1965.

I. meeboldii C.E.C. Fischer
Mysore, Karnataka—apparently grows in rice fields as a weed.
No specimens in MH.

I. setosa C.E.C. Fischer
Cochin, Ernakulam Dt., Kerala and Travancore.
Recently located in Lockhert gap, Devicolam, Idikki Dt., Kerala during 1963.

Limnopoa meeboldii (C.E.C. Fischer) C. E. Hubbard
Coelachne meeboldii C.E.C. Fischer
Chalakudi, Trichur Dt., Kerala—in tanks.
No specimens in MH.

Ochlandra beddomei Gamble
Wynaad, Kerala.
No specimens in MH.

Zenkeria sebastinei Henry & Chandr.
Agastyamalai, Tirunelveli Dt., Tamil Nadu.

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BILATERAL SYMMETRY IN THE REPRODUCTIVE STRUCTURES OF SOME PALMS

T. Antony Davis[1] and C. Bhattacharya[2]

(*With twelve figures*)

Introduction

The alternate spiral phyllotaxis in palms results in the emergence of left- and right-handed crowns (Davis 1971). On account of their spiral arrangement in the crown, the leaves have turned asymmetrical bilaterally, the number of leaflets on one half remaining greater than that on the other half in most species (Davis *et al.* 1971). As clearly demonstrated by the giant inflorescence of *Corypha umbraculifera,* the spadix has to be regarded as a modified vegetative shoot. Therefore, the spathes and bracts only represent leaves, and they are distributed spirally on the peduncle. As the spikes develop from the axils of spathes/bracts, they also show spiral arrangement. Secondary branches of spikes, where present, invariably are placed spirally. Flower-clusters, especially the triads, are distributed spirally on the spikes, and so, a spike may be regarded as left-handed or right-handed according how the clusters are positioned. The perianth of both male and female flowers show bilateral symmetry in their aestivation. Some of the associations mentioned above were examined and quantitative data recorded on the following species:

Areca catechu,
Arenga pinnata,
Calyptrocalyx spicatus,
Caryota mitis,
Caryota urens,
Chrysalidocarpus lutescens,
Cocos nucifera,
Ptychosperma elegans, and
Ptychosperma macarthurii.

The comprehensive problem of levo- and dextro-rotatory phenomena occurring in nature, especially those manifested by plants and animals is being investigated at the Indian Statistical Institute, and the observations recorded in this paper form part of the programme.

Presentation of data

1. **Ptychosperma macarthurii**

This is an elegant clustering palm, generally propagated by seed although multiplication through suckers is no less frequent. The seedling starts producing suckers only after about a year, by which time, the main shoot stands distinctly bigger than the suckers. Even in fairly older clumps, this growth difference between the main stem and suckers is more or less maintained for a couple of years. The spirality of the main shoot and that of the suckers were recorded in 13 clumps at the Indian Statistical Institute and the Indian Botanic Garden, Calcutta. The data are presented in Table 1.

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[2] Indian Statistical Institute, Calcutta-700 035.

TABLE 1

Ptychosperma macarthurii : SPIRALITY OF MAIN SHOOT AND SUCKERS

Spirality of main shoot	No. of clumps examined	Spirality of suckers		
		Left	Right	Total
Left	9	20	22	42
Right	4	9	12	21
Total	13	29	34	63

From data given in Table 1, it is obvious that there is no significant association between the spirality of the main stem and that of offshoots.

Association between stem and spadices

From the positions of individual spikes developing on the peduncle, it is not difficult to recognise right- and left-handed spadices. The distribution of the two kinds of spadices on the same stem is not random, but a positive association has been found to exist between the spirality of the palm and that of its spadices as evident from data given in Table 2. Out of 84 spadices examined from 16 left-spiralled palms, 60.70 per cent of the spadices happened to be left-spiralled. Similarly, in the right-spiralled palms, 77.70 per cent of the spadices were right-spiralled, and the association is significant statistically. The *chi* square values to test the deviation from equality are 3.86 and 13.89 respectively.

Handedness of spadix and spikes

The flower clusters (triads) are spirally arranged on the spikes (Fig. 1), and left- and right-handed spikes are distinguishable. Here again, a positive association exists between the spirality of the spadix and that of its spikes.

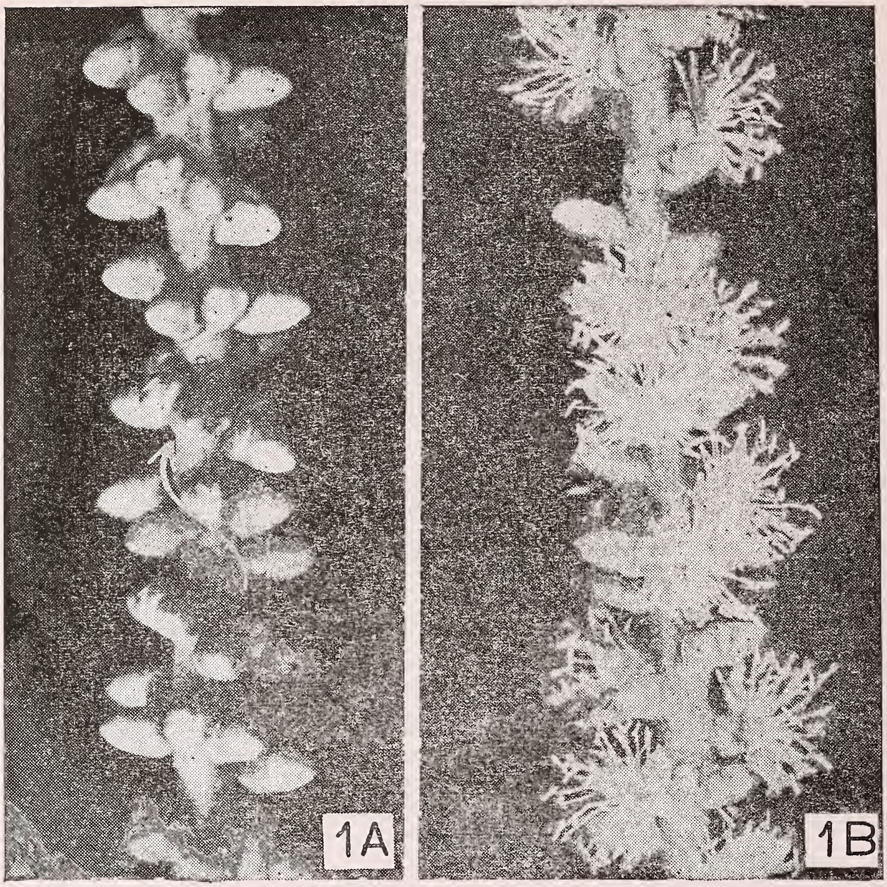
TABLE 2

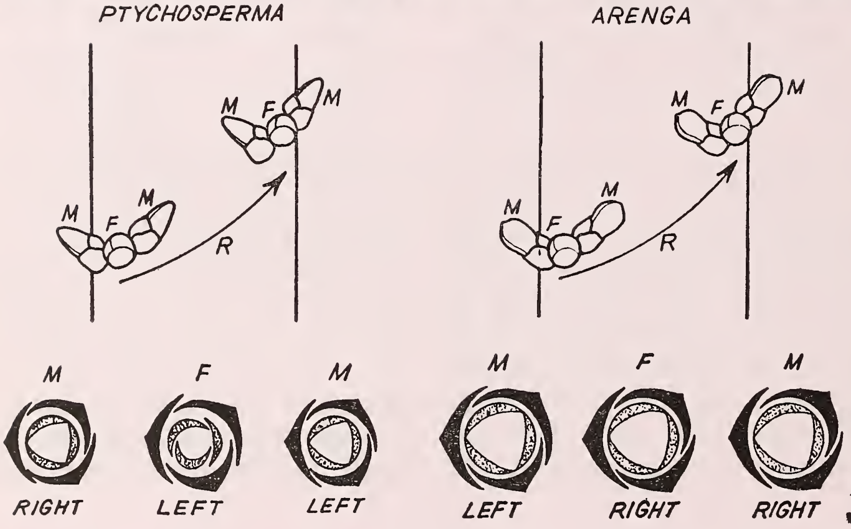
Ptychosperma macarthurii: SPIRALITY OF STEM AND THAT OF SPADICES AND SPIKES

Number of	Spadices		Spikes		
palms	spirality	number	spirality	number	percentage
Left 16	Left	51	Left	729	67.80
			Right	345	
	Right	33	Left	329	64.50
			Right	417	
Right 9	Left	10	Left	142	63.10
			Right	83	
	Right	35	Left	225	63.80
			Right	398	
Total 25	L + R	129	L + R	2,668	

Aestivation of palm flowers

In palms, generally three distinct kinds of aestivation are met with which are depicted in Fig. 2. The simplest is the valvate type where the margins of perianth segments just meet. This type is commonly met with in the corolla of staminate and hermaphrodite flowers. The partial drawings of two male flowers A and




PTYCHOSPERMA
ARENGA
M
F
M
R
M
F
M
R
M
F
M
M
F
M
R
M
F
M
M
F
M
RIGHT
LEFT
LEFT
LEFT
RIGHT
RIGHT

3

Fig. 1. Portions of flowering spikes of *Ptychosperma macarthurii*. A—flower clusters (triads) arranged clockwise; B—with bloomed male flowers.

Fig. 3. Aestivation of perianth of male and female flowers of *Ptychosperma* and *Arenga* triads.

B in Fig. 2 have valvate petals. In such flowers, the petals do not overlap even in bud. The sepals in A and B as well as the petals in C and D show imbricate aestivation (overlapping of perianth not in a regular order) which is the most frequent type met with in palms. The calyx in both male and female flowers of most species of palms is imbricate. Also the corolla in female flowers of many species is imbricate. In this type of aestivation, of the three sepals/petals, one member (outermost) is fully exposed, and the innermost one is overlapped on either side by the other two perianth segments. Thus, one end of the third (middle) sepal/petal is overlapped by the outermost segment, while its other end overlaps the innermost member partially. Two kinds of imbrications can be made out from the manner how the middle segment is placed. If the right end of this segment is free, the aestivation is right-imbrication (A & C), and if the left end is free, it is left-imbrication (B & D). The third kind of aestivation is contortion which is also spoken of as regularly twisting (or merely twisting). Here all the members of a whorl overlap in a uniform manner. Only exceptional flowers of palms have contorting calyx. A flower of *Areca catechu* in Table 20 has contorting calyx. In many species, the corolla of some flowers contort while that of others imbricate. We have not come across any species where all the female flowers have only contorting corolla. Even in flowers having contorting corolla, in one, all the petals may rotate to the right (E) and in another to the left (F). Thus, there are four patterns of petal aestivation displayed by many species. But some species like *Ptychosperma macarthurii* have only two types.

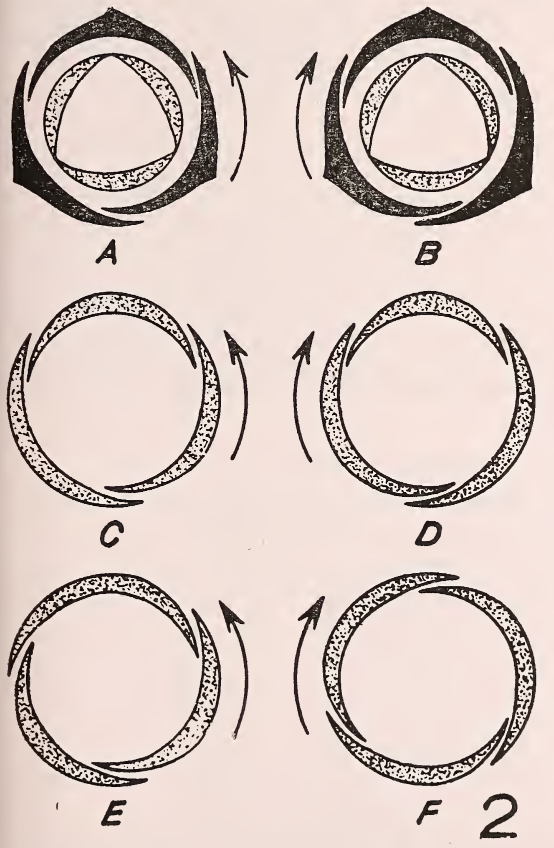


Fig. 2. Partial floral diagrams showing different kinds of aestivation of perianth segments in palms.

Aestivation of perianth of male and female flowers

The flowers are arranged in clusters of three of which the middle one is female and the lateral two are males. When the spike is held vertically with the distal end up, the three flowers in each cluster will lie almost horizontally. The male towards the left-hand side of the observer is regarded (for the sake of description) as left male and that towards the right-hand side as right male. It is most striking that the aestivation of sepals of one male is a mirror-image of the other male. The petals are valvate. The left male in *P. macarthurii* has invariably right-handed imbrication and the right male, left-handed imbrication (Fig. 3, see page 700). Only small exceptions to this rule were noticed as evident from data given in Table 3.

It may be emphasized that the spirality of either the spikes or the spadix has any influence on the kind of imbrication of calyx in male flowers. But the female flowers show a different picture.

The female flowers of *P. macarthurii* have always imbricate sepals and imbricate petals (Fig. 4). An interesting association was discovered between the spirality of the spike and the kind of aestivation of the female flowers. That is, in a left-handed spike, a greater number of female flowers show left-handed imbrication of sepals, and vice versa, in a right-handed spike. Thus, the aestivation of calyx is associated with the spirality of the spike. (vide data in Table 4).

TABLE 3

Ptychosperma macarthurii : AESTIVATION OF MALE FLOWERS IN TRIADS

Tree	Spadix	Spikes	male-flower combination			
			RL	LL	RR	Total
Left	Left 2	Left 21	1468	2	2	1472
		Right 6				
	Right 2	Left 6	968	1	—	969
		Right 15				
Right	Left 1	Left 18	1428	—	1	1429
		Right 4				
	Right 1	Left 5	707	—	2	709
		Right 11				

TABLE 4

P. macarthurii: AESTIVATION OF FEMALE FLOWERS

Tree	Spadix	Spikes	Female flowers			
			sepals		petals	
			Left	Right	Left	Right
Left	Left	Left 5	85	35	34	86
		Right 6	51	116	115	52
	Right	Left 6	79	69	69	79
		Right 6	60	64	63	61
Right	Left	Left 16	201	159	166	194
		Right 15	161	194	191	162
	Right	Left 3	38	20	23	35
		Right 6	29	82	78	33
L + R		Left 30	403	283	292	394
		Right 33	301	456	447	308

A mirror-image situation was met with between the aestivation of sepals and that of petals in the same flower. In a left-spiralling spike, a greater number of flowers have their sepals imbricated left-handed. But the petals, on the other hand, show just the reverse pattern. Therefore, the sepals are almost exactly opposite to the petals for their imbrication/contortion (Davis, 1974).

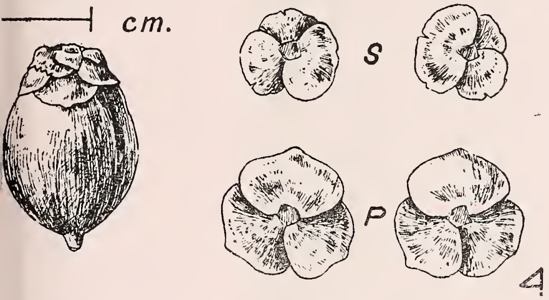


Fig. 4. Fruit of *P. macarthurii* and drawings of imbricating calyx and corolla.

2. **Ptychosperma elegans**

This species, native to Queensland (Australia) is generally single-stemmed and possesses a stem stouter than that of *P. macarthurii*. The crown is also larger, and so, the leaves and spadices are larger than those of *P. macarthurii*.

Two spadices from a left-handed palm and nine spadices from a right-handed palm were studied. A small degree of positive association between the spiralities of spadix and spikes was observed as per data given in Table 5.

TABLE 5

Ptychosperma elegans : SPADIX AND SPIKES

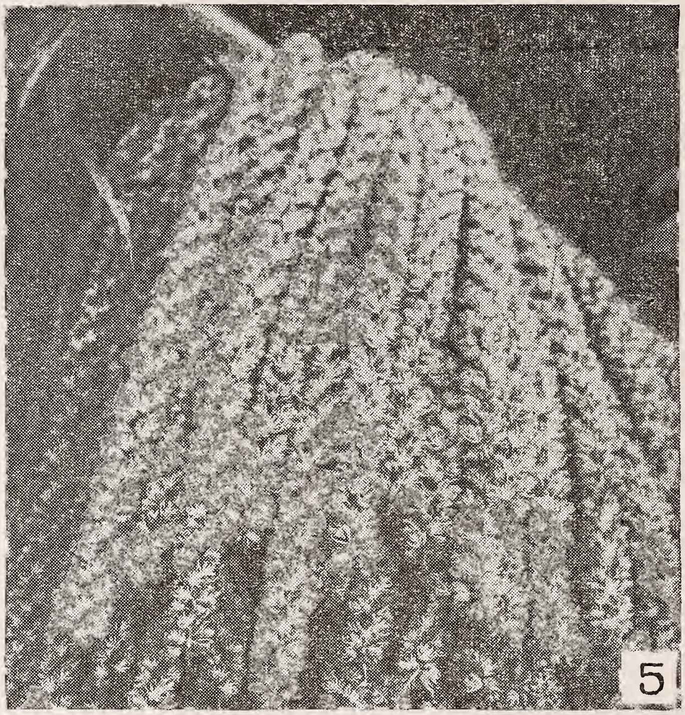
Tree	Spadix	No. L. spikes	No. R. spikes	Total
Left	Left 1	38	27	65
	Right 1	65	57	122
Right	Left 4	287	290	577
	Right 5	293	400	693
	Total 11	683	774	1457

The flowers are arranged typically in triads. A small sample of flower-clusters from a left-handed and a right-handed spikes was examined for the aestivation of sepals. As in *P. macarthurii*, the male on the left side has counter-clockwise imbrication of sepals and the right male has clockwise imbrication. In

TABLE 6

Ptychosperma elegans: AESTIVATION OF FEMALE FLOWERS (CALYX)

Tree	Spadix	Spikes	Flowers		
			Left-handed	Right-handed	Total
Left	Left	Left 8	80	61	141
		Right 2	37	45	82
	Right	Left 2	411	347	758
		Right 1	166	161	327
Right	Left	Left 3	91	68	159
		Right 3	66	123	189
	Right	Left 3	100	78	178
		Right 3	82	99	181
		Left 16	682	554	1236
		Right 9	351	428	779



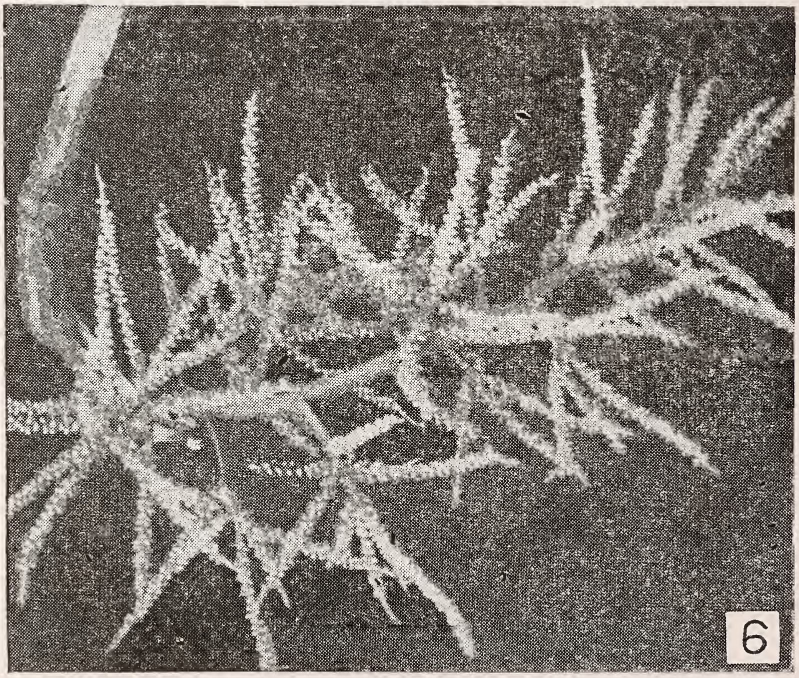


Fig. 5. Spadix of *Caryota mitis* with bloomed male flowers.
Fig. 6. Spadix of *Chrysalidocarpus lutescens* with young flowers.

six per cent of the clusters examined, the males showed LL, RR and LR combinations in their imbrications.

The female flowers from 16 left- and 9 right-handed spikes were examined for the aestivation of calyx, and the data are presented in Table 6.

There is a small degree of positive association between the spirality of the spike and imbrication (of calyx) in female flowers. The petals invariably imbricate opposite to that of the sepals. But the association is not as powerful as in *P. macarthurii.*

3. **Caryota mitis**

Two species of *Caryota* were examined for the bilateral symmetry in their structures. While one of them, *Caryota mitis,* is clustering, the other (*C. urens*) is single-stemmed. *C. mitis* is a profusely suckering, small-stemmed palm commonly used as a tub-plant. But *C. urens* is a large palm bearing massive spadices which when young are tapped for a sweet sap. Since both the species are monocarpic, with the emergence of the first spadix which is terminal, the palm continues to emit flower bunches from leaf axils in basipetal succession during the next 2-3 years.

Spadix of *C. mitis* (Fig. 5) is more compact and shorter than that of *C. urens.* From 3 left-handed and 5 right-handed shoots of *Caryota mitis,* 1,887 spikes were examined for the asymmetry. The samples revealed the existence of a small degree of positive association between the spiralities of spadix and spikes. But, there is a greater degree of negative association between the spiralities of the crown and spadix. However, the data given in Table 7 are very limited to attach much significance to the association.

The flower clusters of *C. mitis* as of *Ptychosperma macarthurii* show the striking phenomenon that the left male has right-imbricating sepals while the right male always shows left-imbrication. This situation does not depend on the condition of the spike as per data given in Table 8. The petals are valvate.

The female flowers of *C. mitis* also bear valvate petals like the male flowers, but the aestivation of the calyx (which is imbricate) shows a higher degree of negative association with the spirality of the spike, which phenomenon is just the reverse of the situation noticed in *P. macarthurii.* The data are presented in Table 9.

TABLE 7

Caryota mitis : ASSOCIATION BETWEEN CROWN, SPADIX AND SPIKES

	Spadix		Spikes		
Tree	Spiral	No.	Lefts	Rights	Total
Left 3	Left	4	141	119	260
	Right	10	253	264	517
Right 5	Left	11	465	369	834
	Right	4	107	169	276
Total	Lefts	15	606	488	1094
	Rights	14	360	433	793

TABLE 8

Caryota mitis: AESTIVATION OF MALE FLOWERS

Tree	Spadix	Spike	Flower-clusters			
			RL	LL	RR	Total
Left	L	Left 2	38	—	—	38
		Right 2	40	—	—	40
	R	Left 1	39	2	—	41
		Right 1	33	—	—	33
Right	L	Left 2	73	—	—	73
		Right 2	80	—	—	80
	R	Left 3	190	1	—	191
		Right 5	251	2	7	260
Total		Left 8	340	3	0	343
		Right 10	404	2	7	413

TABLE 9

Caryota mitis: AESTIVATION OF FEMALE FLOWERS

Tree	Spadix	Spike	Flowers		
			Left	Right	Total
Left	Left	Left 3	18	43	61
		Right 3	42	21	63
	Right	Left 10	100	165	265
		Right 5	113	60	173
Right	Left	Left 4	59	83	142
		Right 3	81	36	117
	Right	Left 7	107	224	331
		Right 8	299	174	473
Total		Left 24	284	515	799
		Right 19	535	291	826

4. **Caryota urens**

A total of 15 spadices from three left-handed and three right-handed *C. urens* palms were examined. As per data given in Table 10, out of 933 spikes from 8 spadices of the left-handed palms, 503 were left-spiralled, which is roughly in a one: one ratio. However, when the left-spiralled spadices alone are considered, there is an excess of left-spiralled spikes.

TABLE 10

Caryota urens : ASSOCIATION BETWEEN SPADIX AND SPIKES

Tree	Spadix	No. of L. spikes	No. of R. spikes	Total
Left 3	Left 4	224	192	416
	Right 3	89	105	194
Right 3	Left 4	279	238	517
	Right 4	159	192	351
Total	Left 8	503	430	933
	Right 7	248	297	545

The positions of male and female flowers on the spikes are similar to those of *Caryota mitis* or *Ptychosperma macarthurii.* It is also striking that the calyx of the left male flower imbricates always right-handed irrespective of the spirality of the spike of its origin. Similarly, the right male flower has left-handed imbrication. The data are shown in Table 11.

TABLE 11

Caryota urens: AESTIVATION OF MALE FLOWERS

Tree	Spadix	Spikes	Flowers				Total
			RLL	RRL	RRR	RL	
Left	Right	L	47	106	2	—	155
		R	126	51	—	2	179
		Total	173	157	2	2	334

In female flowers, the calyx imbricates and the corolla is always valvate. Right- and left-spiralled spadices from right- and left-handed *C. urens* palms were collected. Three left-spiralled and three right-spiralled spikes from each spadix were examined for the aestivation of sepals of female flowers. In all spikes the imbrication of the majority of female flowers was found negatively associating with the spirality of the spike. This situation in this species is much more pronounced than in *C. mitis* as per data presented in Table 12.

Data on the nature of each female flower for the aestivation of calyx were recorded in the order of the distribution of the flowers on the spikes (from base upwards). A critical examination of the data suggested that a majority of flowers having the calyx imbricating opposite to the spiral of the spikes appeared to cluster more within the lower one-third distance of the spike. Towards the tip, the flowers invariably bore calyx whose direction of imbrication matched with the twist of the spike.

5. Arenga pinnata

The spadix of *Arenga pinnata* more or less resembles that of *Caryota* and *Ptychosperma* by having the male and female flowers arranged in clusters of three throughout the length of the spikes. But the following unique features were noticed in this species. The first spadix which is invariably the terminal one,

TABLE 12

Caryota urens : AESTIVATION OF CALYX IN FEMALE FLOWERS

Tree	Spadix	Spike	Female flowers (aestivation)		
			Left-handed	Right-handed	Total
Left	Right	Left	17	126	143
		Left	27	168	195
		Left	39	170	209
		Sub-total	83	464	547
		Right	182	28	210
		Right	135	42	177
		Right	151	29	180
		Sub-total	468	99	567
Right	Left	Left	60	138	198
		Left	48	180	228
		Left	50	107	157
		Sub-total	158	425	583
		Right	183	53	236
		Right	155	31	186
		Right	130	57	187
		Sub-total	468	141	609

as well as a couple of spadices formed immediately after, bear only female flowers. These flowers appear solitary and are arranged spirally on the spike instead of being in triads. In the subsequently formed spadices, the male flowers start appearing gradually, and each cluster shows the usual two males and a female pattern. In spadices formed towards the end of the flowering phase of the palm, each cluster produces only a pair of male flowers, the females getting suppressed. In extreme cases, a cluster, especially at the tip of spikes, is represented by a single male flower.

From three right-handed palms, 13 spadices and from a left-handed palm two spadices

TABLE 13

Arenga pinnata: SPIRALITY OF SPADIX AND SPIKES

Tree	Spadix	Left-handed spike	Right-handed spike	Total
Left-handed	Left 1	17	20	37
	Right 1	22	17	29
Right-handed	Left 3	33	67	100
	Right 10	197	198	395
	Left 4	50	87	137
	Right 11	219	215	434

TABLE 14

Arenga pinnata : AESTIVATION OF MALE FLOWERS

Tree	spadix	spike	Flowers				Total
			LR	LL	RR	RL	
Left-handed	Left-handed	Left-handed	41	18	6	1	66
		Right-handed	46	5	14	1	66
Right-handed	Right-handed	Left-handed	91	1	2	0	94
		Right-handed	179	5	2	0	186

Note : The deviations proportionately are higher than those in *Caryota* sp.

TABLE 15

Arenga pinnata : AESTIVATION OF FEMALE FLOWERS

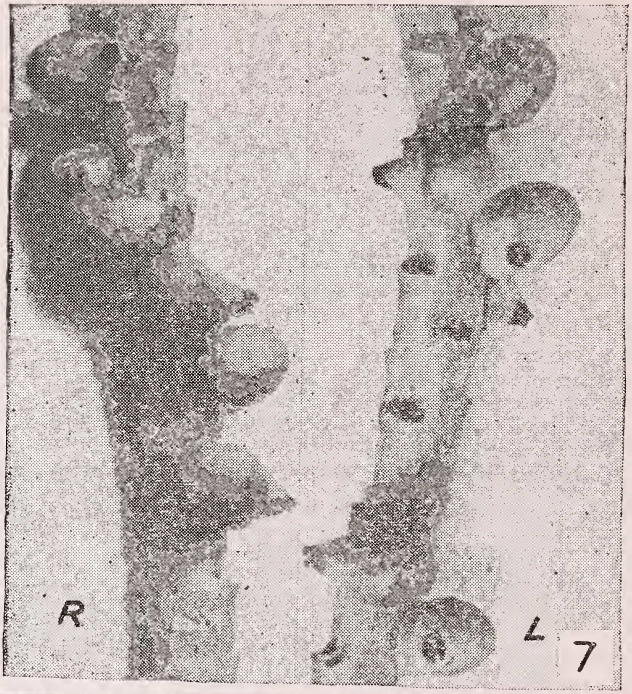
Tree	Spadix	Spike	Flowers			Total
			Left	Right	X	
Left-handed			Data not available			
Right-handed	Left-handed	Lefts 3	59	226	12	297
		Rights 3	284	64	34	382
	Left-handed	Lefts 3	87	190	14	291
		Rights 3	149	68	17	234

X—where spirality could not be determined.

were collected and the spirality of the spadices and spikes examined. A negative association was found to exist. That is, left-spiralled spadices produced more of right-spiralled spikes, and right-spiralled spadices, a slight excess of left-spiralled spikes (Table 13). However, this is a clear departure from the situation noticed in *Caryota* and *Ptychosperma.*

The calyx of both the male and female flowers of *Arenga pinnata* imbricates while the petals in both the flowers are valvate. The left male in each cluster shows left-handed imbrication and the right male, right-handed imbrication. This arrangement is not influenced by the spirality of the spikes. So it is spectacular that the kinds of imbrication in the male flowers of *Arenga* are exactly the reverse of those of males in *Caryota* and *Ptychosperma.* That is, a left male flower in *Arenga* is left-handed, whereas the same in *Caryota* or *Ptychosperma* is right-handed. Similarly, the right male in *Arenga* is right-handed, but left-handed in *Caryota* or *Ptychosperma.* The cause for such a double enantiomorphism in the aestivation of the calyx of male flowers is yet to be known. Table 14 presents data on the aestivation of male flowers of *Arenga pinnata.*

The aestivation of the female flowers, however, associates negatively with the spirality of the spikes. In a left spike, a great majority of the females have right-imbricating calyx, and vice versa in a right spike. Data obtained from only one tree are presented in Table 15. Thus, *A. pinnata* in this respect is opposed to *Ptychosperma* species.



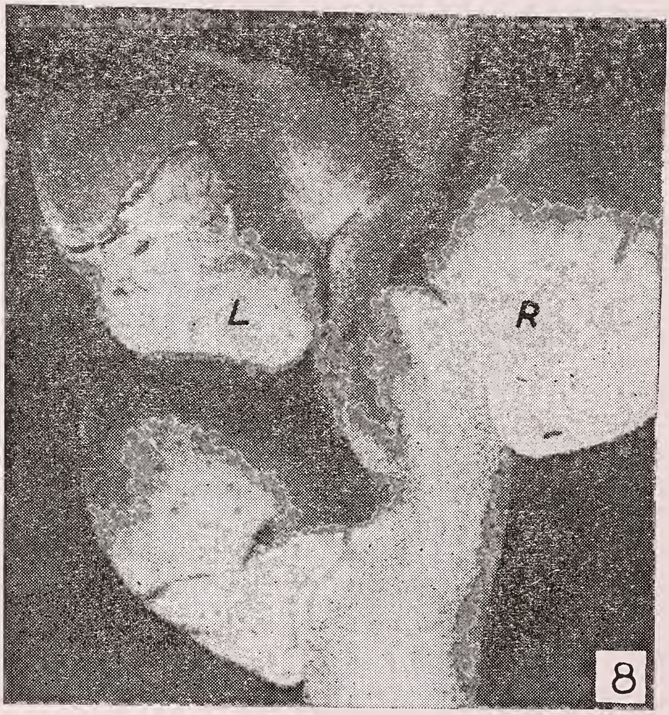


Fig. 7. *C. lutescens*: Right- and left-spiralled spikes bearing young fruits.

Fig. 8. Portion of coconut spike bearing 3 female flowers having imbricate perianths.

TABLE 16

Chrysalidocarpus lutescens : ASSOCIATION OF CHARACTERS

Shoot Spirality	No.	Spadix Spirality	No.	Spikes Lefts	Rights	Total
Left	9	Left	6	201	225	426
		Right	18	433	455	888
Right	8	Left	10	410	363	773
		Right	3	119	113	232
Total	17	L+R	37	1163	1156	2319

6. Chrysalidocarpus lutescens

Chrysalidocarpus lutescens, another elegant clustering ornamental palm with arching leaves and yellowish-green stem, shows a negative association between the spirality of crown and that of the spadix (Fig. 6). But between the spadix and spikes, no significant association was found among the specimens sampled from 17 shoots. The data are given in Table 16.

The flowers of *C. lutescens* are so small that sorting out the flowers according to the type of aestivation was very difficult. Moreover, the triads are not formed in regular order, but are very much crowded. Hence data on flower-clusters as well as flowers could not be collected. But the young fruits reveal an interesting asymmetry. In Fig. 7 are seen portions of left-spiralled (L) and right-spiralled (R) spikes from a spadix of *C. lutescens.* The young fruits assume a peculiar shape. Out of the three carpels (ovaries) in a fruit, generally only one develops. In a right-spiralled spike, the left-most carpel in each fruit develops. Due to this unilateral development, the two abortive carpels and the common stigmatic-end are pushed to the right side. Such a picture is shown by all the young fruits on the right-spiralled spike. A mirror-image form is noticed on the left-spiralled spike since the developed carpel in each fruit is on the right, and the stigmatic-end is pushed to the left. Such a pattern of development of the ovary is not so far noticed in any other species. But some species of *Phoenix* and *Cocos nucifera* are likely to manifest a comparable picture.

7. Cocos nucifera

The coconut palm also displays some mirror-image patterns between asymmetrical structures in its reproductive organs.

108 spadices from 16 palms were examined for the kind of handedness in spikes and spadices. A small degree of positive affinity between a right-handed palm and a right-spiralled spadix, as well as between a right-handed spadix and a right-spiralled spike. Data obtained earlier by Ghosh (1978) on 9 trees, also from Calcutta, gave almost similar results with some affinity among right trees, right spadix and right spikes. The combined data are presented in Table 17.

The male flowers of *Cocos nucifera* have imbricate sepals and valvate petals. But in about 50 per cent of them, the sepals remain partially valvate and partially imbricate. In the female flowers (Fig. 8), the sepals are clearly imbricate, and the petals either imbricate or twist regularly (contort) (Davis and Basu, 1971). All available types of aestivation of calyx and corolla in *Cocos nucifera* fruits are shown in Fig. 9.

TABLE 17

Cocos nucifera : ASYMMETRY IN THE SPADIX

Tree		Spadix	Spikes			
Spiral	No.	Spiral	No.	Lefts	Rights	Total
Left-handed	10	Left-handed	36	604	592	1196
		Right-handed	37	566	656	1222
Right-handed	15	Left-handed	44	760	722	1482
		Right-handed	61	984	1140	2124
Total	25	L+R	178	2914	3110	6024

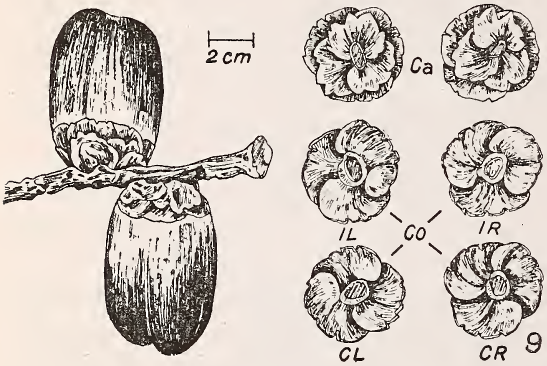


Fig. 9. Perianth types in coconut fruits.

There is a tendency for the calyx to associate negatively with the spirality of the spike on which they develop as per figures given below:

Left-spiralled spikes (16 nos.) :
Left-twisting flowers .. 72,
Right-twisting flowers .. 106,
Right-spiralled spikes (16 nos.) :
Left-twisting flowers .. 61,
Right-twisting flowers .. 60.

Similarly, there is no strong association between the aestivation of sepals and that of petals as per data summarised in Table 18.

In an abnormally large spadix of coconut reported by Ghosh (1978), each spike bore 3-19 female flowers instead of the usual single flower. The terminal of the peduncle also bore 26 female flowers. Moreover, at the lowermost position in 16 of these spikes, there were twin female flowers (Fig. 10).

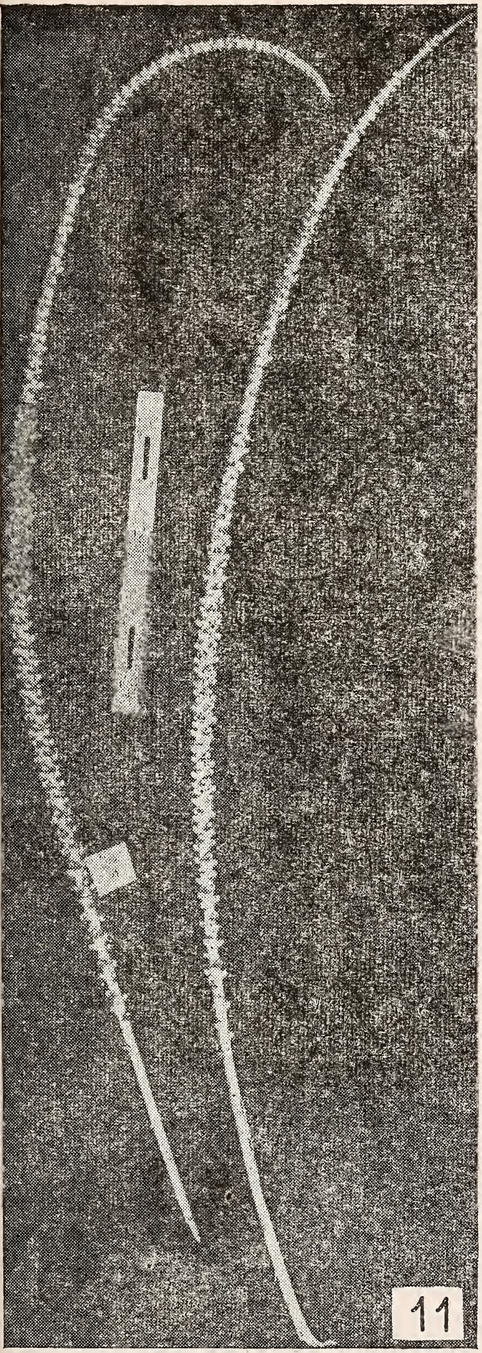
TABLE 18

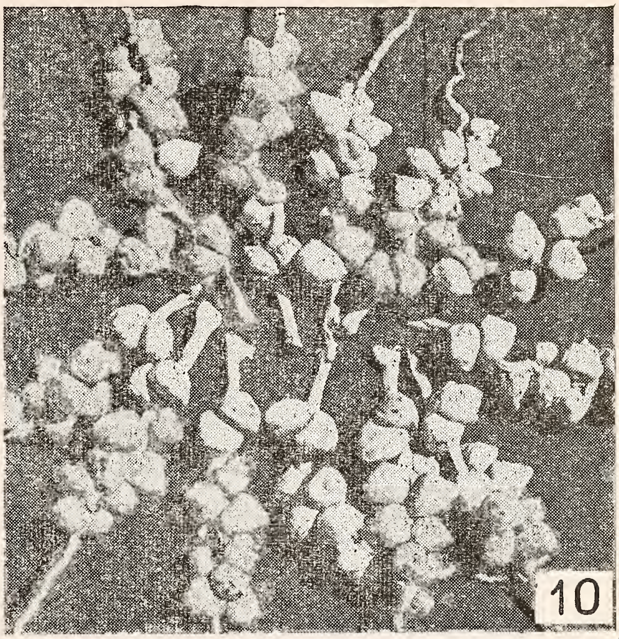
Cocos nucifera : CALYX-COROLLA ASSOCIATION

	Imbrication + Contortion of petals		
Sepals	Left	Right	Total
Imbricate left	231	334	565
Imbricate right	243	251	494
Total	474	585	1059

The aestivation of calyx in the twin female flowers is interesting as these flowers imitate the situation prevalent in the male flowers of *Caryota* or *Ptychosperma*. All the females on the left side, irrespective of the spirality of their spikes imbricate to the right, and all the females on the right have left-handed sepal imbrication. The petals, however, did not show any distinct pattern.

Most of the male flowers in *Cocos nucifera* appear in pairs throughout the spike above the limit of female flower(s). Each female flower is bordered by two males. Wherever the calyx of both the flowers in a pair was regularly imbricating their spirality was recorded. The data obtained from 223 twin males unmistakably show that in coconut, the





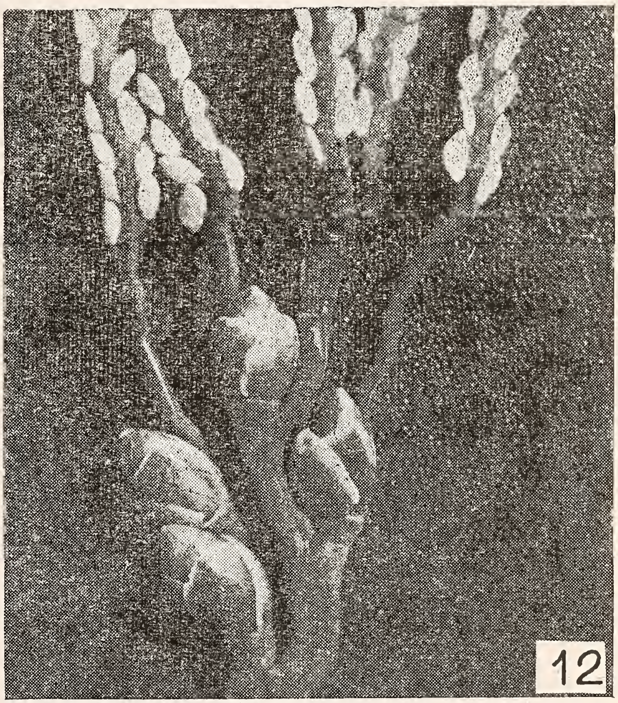


Fig. 10. Spikes of a large coconut spadix, each bearing many female flowers. Each spike bears a twin female flower at base.

Fig. 11. Two spadices of *Calyptrocalyx spicatus.*

Fig. 12. Portion of *Areca catechu* spadix. Male flowers arranged in two rows.

male twins deviate from the unique association displayed by *Caryota* or *Arenga* as the data in Table 20 reveal.

TABLE 19

Cocos nucifera : AESTIVATION OF TWIN MALE FLOWERS

Tree	Spadix	Spike	Flowers				
			RR	RL	LL	LR	Total
Left-handed	Left-handed	Left-twisting	28	21	20	1	70
		Right-twisting	20	22	6	6	54
Right-handed	Left-handed	Left-twisting	7	18	23	2	50
		Right-twisting	20	23	3	3	49
		Total	75	84	52	12	223

8. **Calyptrocalyx spicatus**

Calyptrocalyx spicatus is characterised by having a long, cylindrical and unbranched spadix (Fig. 11) where the flowers, arranged in clusters, are partially covered by semi-circular bracts. By following the arrangement of the bracts, right- and left-spiralled spadices can be made out. Unlike the Caryotoid/Ptychospermate palms, a flower cluster in *Calyptrocalyx spicatus* consists only of one male flower and a female flower. An impressive symmetry has been observed from the positioning of the male flower in each cluster. In a left-spiralled spadix, the male flower (in each cluster) appears on the left side of the female when viewed by holding the spike vertically, and in a right-spiralled spike, the male is on the right of the female.

The sepals of the male flowers of *Calyptrocalyx* are imbricating but the petals are valvate. From the aestivation of calyx, two kinds of male flowers can be distinguished, left-handeds and right-handeds. A great majority of male flowers of the left-spiralled spikes have right-handed imbrication. Similarly, a great majority of males on right-spiralled spike have left-handed imbrication. The small degree of deviation is noticed only towards the base of the spike as was observed in *Caryota urens.*

Since the female flowers in the spikes at the time of observation were too immature to observe their perianth, data for the aestivation of the female flowers are not available.

9. **Areca catechu**

Of the species of palms included for the present investigation, *Areca catechu* is the least pronounced with regard to asymmetry in the spadix. The peduncle of the spadix is considerably flattened and compressed and the main branches of spadix appear as though the flattened stalk has been split vertically. Hence the spirality of the spadix cannot be made out accurately. Again, the male flowers are arranged in two parallel rows throughout the upper two-thirds the length of the ultimate spikes (Fig. 12). Therefore the spikes also do not display any spirality.

Although the aestivation of calyx of male flowers is difficult to observe, careful observations have shown that all the flowers on one row show the same kind of aestivation which is opposite to that of flowers on the other row. The condition of males in small portions of two spikes is shown in Table 20.

TABLE 20

AESTIVATION OF *Areca catechu* MALE FLOWERS

Spike 1		Spike 2	
Flr. on left	Flr. on right	Flr. on left	Flr. on right
IR	IL	IR	CR
IR	IL	IR	IL
IR	IL	IR	IL
IR	IL	IR	IL
IR	IL	IR	IL

IR—Imbricating to the Right; IL—Imbricating to the Left;
CR—Contorting to the Right.

TABLE 21

Areca catechu : CALYX-COROLLA ASSOCIATION

Sepals	Petals				Total
	Left imbricate	Right imbricate	Left contort	Right contort	
L imbricate	460	468	124	124	1,176
R imbricate	458	425	116	101	1,100
Total	918	893	240	225	2,276

Since the spike is flat and the rows of male flowers occupy the margins of spikes, the spike gives practically the same view from both the surfaces. Therefore, which side bears the right imbricate and which side the left imbricate flowers is difficult to decide. The perianth of female flowers shows clear asymmetry in their aestivation. Sepals are always imbricate, but the petals in some flowers imbricate while in others contort, a situation similar to that recorded for *Cocos nucifera.* Data obtained earlier by Davis and Kundu (1967) on the calyx-corolla relationship are presented in Table 21.

A perusal of the data in Table 21 suggests that there is no association between the aestivation of calyx and corolla. In this respect *Areca catechu* resembles *Cocos nucifera* closely.

Number of spikes per spadix

Among the 9 species of palms investigated, *Calyptrocalyx spicatus* has an unbranched, simple spicate type spadix. But *Areca catechu* has the largest spadix each bearing over seven hundred and fifty spikes. The figures relating to the 9 species are given in Table 22.

In four of the above species, the average number of spikes per spadix is more for the right-spiralled spadix, in four others, the left-spiralled spikes have an excess of spikes and one shows equality. Presumably, the spadices examined from *Arenga pinnata* were very

TABLE 22

DATA ON SPADICES OF 9 SPECIES OF PALMS

Species	Trees		Spadices		Mean spikes per spadix	
	Left	Right	Left	Right	Left	Right
Areca catechu	1	1	—	—	775.3	759.0
Arenga pinnata	0	1	3	3	32.3	39.0
Calyptrocalyx spicatus	1	0	1	1	1.0	1.0
Caryota mitis	1	3	8	6	73.4	98.5
Caryota urens	2	2	8	7	94.4	103.8
Chrysalidocarpus lutescens	9	8	16	21	66.4	55.0
Cocos nucifera	7	9	49	59	35.4	31.6
Ptychosperma elegans	1	1	5	6	68.3	77.4
Ptychosperma macarthurii	16	9	61	68	21.7	18.2

much reduced in size as indicated by the small number of spikes per spadix.

SUMMARY

Biometrical studies made on the handedness of reproductive structures of nine species of palms revealed the prevalence of some very important association between various organs. The most striking phenomenon is that which is perceivable in the aestivation of calyx between the two male flowers of each triad in *Ptychosperma* sp., *Caryota* sp., and *Arenga pinnata*. In each cluster of *Ptychosperma* or *Caryota*, the left male flower has right-handed imbrication, and the right male always shows left-handed imbrication. Inexplicably, in *Arenga pinnata*, on the other hand, the left male in each cluster shows left-handed imbrication, and the right male is always right-handed for the aestivation of calyx. Thus, the asymmetry of male flowers in each triad in *Arenga* is mirror image to that in *Ptychosperma*/*Caryota*. Such a situation may be regarded as double enantiomorphism. In *Calyptrocalyx spicatus*, the only male in each cluster occupies the left of female in a right-spiralled spike, and on the right of female in a left-spiralled spike. The aestivation of the male here has more resemblance to that of *Arenga pinnata*. The calyx and corolla in each female flower/fruit of *Ptychosperma macarthurii*, always show opposite kinds of imbrications. However, in other species, this peculiarity is either less prominent or it does not occur.

In *Arenga pinnata*, majority of the female flowers borne on left-spiralled spikes have right-imbricating calyx, and the majority on right-spiralled spikes have left-imbricating calyx. But the situation is reversed in *Ptychosperma macarthurii*. *P. elegans* also maintains such an arrangement. But most unexpectedly, both *Caryota mitis* and *C. urens* imitate *Arenga pinnata* in this regard by displaying positive association between the spirality of spike and the aestivation of calyx in a majority of female flowers. It may be noted that *Arenga* and *Caryota* behave differently with regard to the aestivation of male flowers.

In the matter of handedness of spikes and spadices also, striking association was noticed in some species. *P. macarthurii* is the only species so far investigated which shows a positive association between the handedness of a crown and that of its spadices. Moreover, this species also shows a positive association between the spiralities of spadix and its spikes. *P. elegans* did not show any such association. Both *Caryota mitis* and *C. urens* manifest a degree of positive association between the spiralities of spadices and spikes.

Another minor but curious association noticed was with the development of carpel in *Chrysalidocarpus lutescens*. The developing ovary in a fruit always enlarges along the side opposite the spirality of the spike pushing the undeveloped ovaries and the common stigmatic-end towards the opposite side.

ACKNOWLEDGEMENT

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ON FACTORS GOVERNING THE DISTRIBUTION OF WILD MAMMALS IN KARNATAKA

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H. C. Sharatchandra and
Madhav Gadgil[1]

(*With five plates and seven text-figures*)

The forests of Karnataka are largely restricted to hill regions, and depending on the precipitation the forest types range from the evergreen to scrub vegetation. An analysis of food resources available in the various vegetation types shows that the evergreen forests are particularly suited to frugivorous arboreal primates and squirrels, while the deciduous forests offer the best habitat for larger grazing herbivores like the gaur and the deer. Drought resistant ungulates, particularly antelopes are specially adapted to the open dry scrub. The wild life bearing forests areas of Karnataka are divided into six regions, namely North Kanara, Crestline, Malnad, Mysore Plateau, Kollegal Hills and Maidan. Occurrence ratings for the major wild mammals over 86 forest ranges of these six regions have been determined on the basis of field studies. An analysis of this data shows that wild life can be considered abundant only on the Mysore Plateau with Malnad, Kollegal Hills, North Kanara, Crestline and Maidan showing a progressive decline in that order. This decline seems highly correlated with the fragmentation of the habitat; hence it is critical to maintain the integrity of the remaining wild life habitats.

INTODUCTION

With its great diversity of ecological conditions, and its unique position at the confluence of three biogeographical realms, the Indian subcontinent can boast of a diversity of wild life unequalled by any land mass of comparable size in the world. Tragically, the recent decades, particularly since the beginning of the British rule, have witnessed a rapid decimation of our wild life heritage to the point that a large number of species are now on the verge of extinction. The situation obviously calls for serious efforts at conservation, and these have in fact been launched, particularly over the last few years. Very little careful documentation of the status of our wild life, and the problems confronting us in our efforts at its conservation is however available. There are a few general accounts, the most important being those of Prater (1971), Gee (1969) and Krishnan (1975), and a few detailed accounts of specific areas such as those of Schaller (1967) for Kanha, Berwick (1976) for Gir and Nair *et al.* (1977) for the Bandipur-Mudumalai-Nagarhole-Wynaad complex. We also have accounts of a few endangered species such as Daniel and Grubh's (1966) survey of wild buffalo, Davidar's (1978) survey of Nilgiri tahr, Nair and Gadgil's (1978) survey of elephants of Karnataka, and Kurup's (1977) survey of the lion-tailed macaque and

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Nilgiri langur. We however still lack careful documentation of the status of wild life over more extensive areas of the country. The present paper is an attempt to furnish such an account for the state of Karnataka. It is based on field studies extending over a period of four years in various parts of the state. It documents the status of major wild life species in a number of representative forest ranges where wild life still persists. In addition it makes an attempt to bring out the factors governing this distribution. The rainfall pattern over the state, determined by the topography, governs the distribution of natural vegetation. This vegetation has been considerably modified by human interference. The resulting vegetation types differ in the degree of availability of different food resources on which depend the populations of wild mammals. This availability of food resources governs the natural distribution of wild mammalian species, depending on the extent to which the ecological requirements of each species are met by a given vegetation type. This is the distribution of wild mammals that prevailed historically before its decimation in recent times. To understand the present distribution, we must additionally take account of man's deleterious impact in different regions and on different species. This paper is an attempt to present such an account. It is hoped that it will provide a basis of information useful for the future attempts at conservation of wild life in Karnataka.

MATERIALS AND METHODS

This report is based on studies carried out in Karnataka over a period of four years from May 1974—June 1978. We have maintained continuous observations at Bandipur national park over the four years, and fairly extensive observations in North Kanara areas from March 1976 onwards. This has been supplemented by an intensive survey of the Mysore plateau from July to October 1975, a survey of North Kanara areas from August 1976 to January 1977, a survey of the rest of Western Ghats and Malnad areas, and of Kollegal hills from May to July 1977 and a survey of the Ranebennur forest in May 1978. The methods employed in these surveys have been described in detail in our earlier publications, and need not be repeated here (Nair *et al.* 1977, Nair and Gadgil, in press).

These surveys have enabled us to arrive at estimations of the occurrence of major wild mammals in 86 of the forest ranges of Karnataka—which covers substantially all of the forest ranges with significant populations of wild animals. The estimates were based on actual sightings, evidence of droppings, signs of feeding and other spoor and reports from tribals and local field staff. In many places the reports were cross-checked with actual field data and were found to be reasonably accurate. An attempt to arrive at estimates of numbers was made only in the case of elephant populations (Nair & Gadgil, in press). In case of all other mammals the population status was ranked on a five point scale: absent —0, rare—1, present—2, frequent—3, and very common—4. This is admittedly subjective and is essentially a comparative statement, comparing the different ranges for a given species. The population of sambar to be ranked very common will obviously have to be much greater than the population of tiger to be ranked very common! Such qualitative ranking is nevertheless of value in giving a clearer picture of the differences in occurrence in various parts of the state and is adopted here in that spirit. While computing occurrence, we automatically note the presence or absence. From this we shall derive the measure of frequency which is defined as the percentage of total forest ranges within a given region in which a particular species is present. Thus any region under consideration may be characterized by the occurrence value averaged over the constituent forest ranges and a frequency of incidence value with respect to any particular species.

The habitat of that region was further characterized by the prevalent vegetation type, extent of its degradation particularly in terms of the canopy cover and the major plant associations. In addition, the habitat was characterized with respect to its extent of fragmentation. This index was calculated by taking an average of the following ratio for a number of constituent ranges.

$$\frac{Df - Dn}{Df}$$

where Df = distance between the two farthest villages or cultivation or mining in the range.

Dn = distance between the two nearest villages or cultivation or mining in the range.

The ratio ranges from 0 to 1, increasing with the extent of fragmentation of the forest. Admittedly, this too is a crude measure, but serves to indicate well different levels of fragmentation of the forest in different parts of the state.

TOPOGRAPHY

The state of Karnataka lies between latitudes 11°35′ to 18°25′N and longitudes 73°40′ and 78° 40′E with the states of Maharashtra to the north, Andhra Pradesh to the east, Tamilnadu and Kerala to the south and with the Arabian Sea to its west (Figure 1). Geographically it is made up of three distinct regions; karavali or a coastal strip on the west, malnad or the hill region in the middle and maidan or the plains of the Deccan plateau to the east. The coastal strip varies in width from just a few kilometres near Karwar in North Kanara to 50-75 kilometres in parts of South Kanara. This coastal strip is flanked to its east by the hill chain of Western Ghats which runs in a north-south disposition parallel to the west coast. In North Kanara the hills are broken and low with an elevation around 1000 m. South of Bhatkal, however the ghats are continuous and rise to an altitude of 1892 metres in Kudremukh. The ghats rise precipitously to their heights with steep slopes abruptly rising out of the coastal plain. To the east they merge gradually with the Deccan plateau, with a series of hills such as Bababudangiri and Mahadeveshwara Malai rising to considerable heights out of the plateau (Figure 2). The Deccan Plateau is itself an undulating plain at an elevation ranging from 500 to 1000 metres.

PRECIPITATION

This lay of the land governs the pattern of precipitation over the state of Karnataka. The state receives almost all of its rainfall from the southwest monsoon between the months of June and September. This monsoon depends on the moisture laden winds that come from the Arabian Sea. The coastal strip receives annual rains of 3000-4000 mm as these winds come over land. The highest precipitation, however, occurs over the ghats because of the ascent of the air forced by the orography. To the north, where the ghats are low, the precipitation is around 4000-5000 mm, but reaches its maximum of around 8000 mm a year in the Agumbe—Kudremukh region. The rainfall in this region is almost

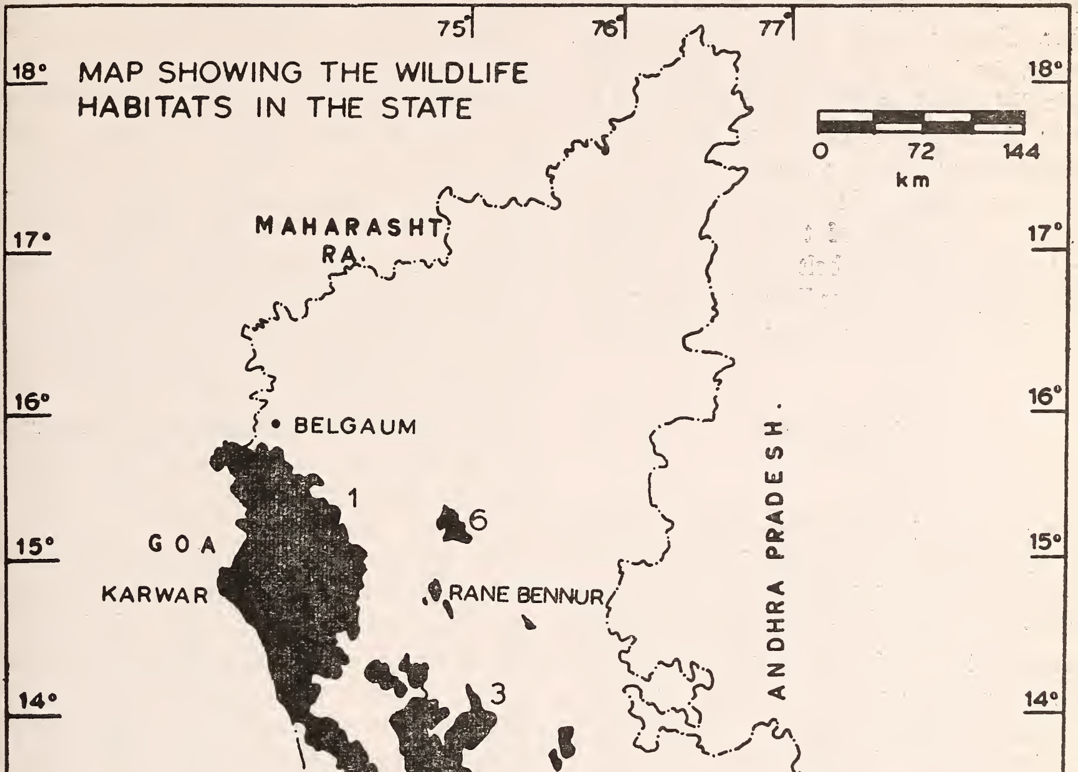

MAP SHOWING THE WILDLIFE HABITATS IN THE STATE
75°
76°
77°
18°
17°
16°
15°
14°
13°
0
72
144
km
MAHARASHTRA
BELGAUM
GOA
KARWAR
RANE BENNUR
ANDHRA PRADESH.
HASSAN
BANGALORE
MANGALORE
MYSORE
KERALA
TAMIL NADU
1
2
3
4
5
6
—·— STATE BOUNDARY
1 NORTH KANARA
2 CREST LINE OF WESTERN GHATS
3 MALNAD
4 MYSORE PLATEAU
5 KOLLEGAL HILLS
6 MAIDAN

Fig. 1. A map of Karnataka State showing the six forest regions.

restricted to the four months from June-September. Further south in the Coorg region, however, the fairly heavy rainfall of 5000-6000 mm is distributed over a longer period of 7-8 months from April-November. The rainfall decreases sharply to the lee of the ghats on the Deccan plateau. It ranges between 600-1000 mm over most of the Deccan plateau, except in the semi-arid belt stretching over the Gulbarga-Bijapur-Raichur-Bellary region where the rainfall is uniformly below 600 mm a year.

VEGETATION

The pattern of natural vegetation over the state of Karnataka is governed essentially by the amount of precipitation, the temperatures reaching a limiting influence only at the higher elevations of the Western Ghats. The coastal plains must in the past have been covered by the mangrove forest near the coast and evergreen forest in the interior plains where rainfall uniformly exceeds 3000 mm. The foot hills of the ghats must also have been covered by evergreen forest in earlier times. The current occurrence of semi-evergreen forest in this high rainfall zone (>3000 mm) seems to be a result of human intervention; the degradation of the evergreen forest has permitted penetration of deciduous tree species in it, imparting semi-evergreen character to the vegetation. The upper slopes and crestline of the ghats receiving precipitation of over 5000 mm a year would have been covered everywhere by evergreen forests. At higher elevations in the ghats the evergreen forest is restricted to hollows as evergreen sholas, with grassy downs covering the exposed slopes. To the east of the crestline the rainfall decreases again, and would support a belt of semievergreen forest in the zone of 2500-3000 mm. The forest would assume a deciduous character further east where the rainfall falls below 2500 mm. The forest would be of the moist deciduous type over a broad belt where the rainfall ranges from 2500-1500 mm a year. Much of the Deccan plateau would under the natural state be covered by a dry deciduous forest, except for the semi-arid tracts with rainfall below 600 mm. These tracts would be covered by a scrub forest (figure 2) (Champion & Seth 1968, Legris 1963, Meher-Homji personal communication).

This pattern of vegetation has been drastically changed by human activity over most of the state of Karnataka. The mangrove forest has entirely disappeared from the coast, and so has the evergreen forest of the coastal plains, to be replaced by paddy and coconut cultivation. The dry deciduous and scrub forests of the maidan area have also disappeared almost entirely, to be replaced largely by cereal crops. The Western Ghats and the adjoining hill tracts, however, still retain some of their forest cover, wherever it has not yet been replaced by plantation crops or other cultivation. This has been heavily exploited by man, generally resulting in the disappearance of evergreen elements from many forests which would originally have been dominated by them. The canopy has been opened everywhere, allowing the forest floor to be invaded by exotic weed species. Wherever rainfall exceeds 1500 mm, the opening of the canopy leads to an invasion by *Eupatorium;* in the dry deciduous forests, the weed species to dominate the vegetation belong to genus *Lantana*. In the drier tracts, exploitation of deciduous forest has often reduced it to the status of a scrub, if not to secondary grassland. In the semi-arid regions the scrub has all but disappeared giving way to a very poor secondary grassland.

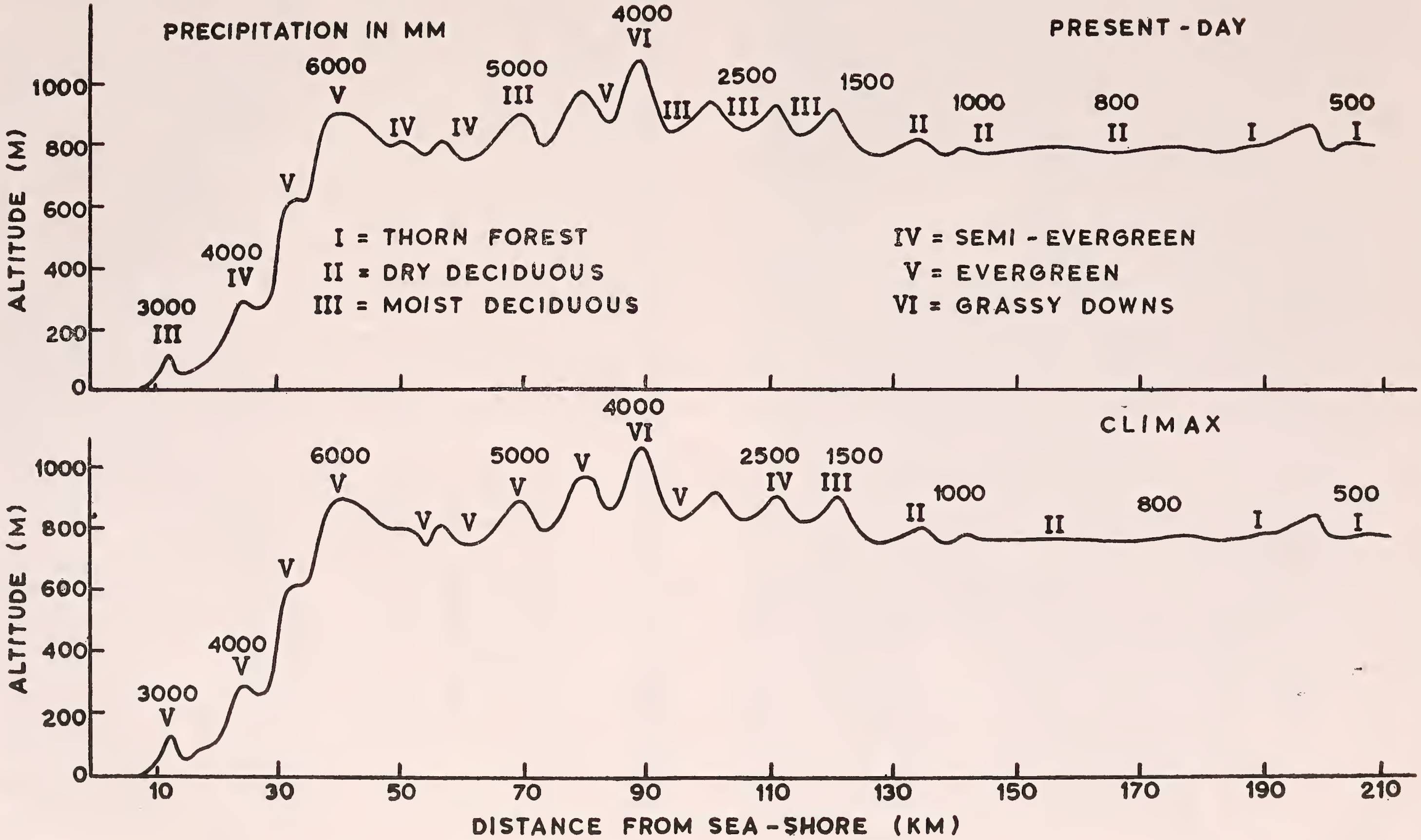


Fig. 2. A schematic cross-section of the Karnataka region indicating the topography, precipitation and climax and present day forest vegetation.

FOOD RESOURCES AND DISTRIBUTION OF MAMMALS

The natural distribution of mammals is ultimately governed by the natural distribution of the vegetation. As heterotrophs, the mammals are dependent on the primary production of the organic matter by the plants. The productivity of the mammalian fauna of any habitat would therefore be related to the productivity of the vegetation. In addition, the composition of the mammalian fauna would depend critically on the specific form in which the plant production is channelised. Thus grazing herbivores would not be able to sustain themselves in an evergreen forest with almost no growth of grass on the forest floor. Frugivores dependent on fleshy fruits would, on the other hand, find abundant food in an evergreen forest. It is therefore most instructive to compare the three major natural vegetation types of Karnataka with respect to the different components of plant production, as well as the production of insects, frogs and lizards.

Evergreen Forest

Table 1 contrasts the distribution of food resources in the pure evergreen, the evergreen shola-grassy downs, deciduous and scrub vegetation in its original climax condition as well as in the degraded form of evergreen, deciduous and scrub vegetation. The degradation is assumed to be to the level at which the canopy is considerably opened but without loss of the basic nature of the forest. The climax evergreen forest has a complete canopy and a fully shaded forest floor covered with leaf litter with no grass and very little other herb growth (See plate 1). Its canopy is at a considerable height from the ground. In consequence there is very little grazing or browsing for ungulates or elephants in such a forest. Bamboos, a favourite food of these animals is also nearly absent from the evergreen forests. The few herbs on the floor belonging to families like Zingiberaceae all tend to have underground storage organs like corms or tubers which are therefore available to the diggers like pigs though the leaves of these herbs are by and large unpalatable. The plant production available to the herbivores in such forests is therefore the tree foliage at the high canopy level and fleshy fruits such as jackfruit, mango and jamun which are so characteristic of evergreen vegetation. Dry fruit and seed are also relatively uncommon. The rich leaf litter on the ground which supports a high level of arthropod fauna, and the prevalent high humidity however supports a very rich amphibian and reptilian fauna in the climax evergreen forests.

An idea of the herbivore and omnivore fauna that such a climax evergreen forest can support can be had from Tables 2 and 3. Table 2 lists the major components of food of the herbivorous and omnivorous mammals of peninsular India. A comparison with the availability of these components in Table 1 allows us to deduce the capacity of the different vegetation types to support these mammals. (Green & Minkowski 1977, Krishnan 1975, Prater 1971, Schaller 1967). It is evident that evergreen forests are particularly rich in the food for arboreal monkeys and squirrels which can feed on fruit and leaves and insects and small vertebrates high up in the canopy. The evergreen forests may also support wild pigs and sloth bear which are omnivores capable of digging up underground corms and tubers. The climax evergreen forests are however a poor habitat for larger herbivores which find little to feed on the floor.

When, however, such forest is somewhat degraded and openings are created in the ca-

Above: A view of the evergreen forest from the Crestline region.
(Photo: *H. C. Sharatchandra*).
Below: A view of the evergreen sholas and grassy downs of Kudremukh from the Crestline region. (Photo: *S. N. Prasad*).

Above: A view of the dry deciduous forest in Bandipur Tiger Reserve, Mysore Plateau. (Photo: *S. N. Prasad*).
Below: The composite weed *Eupatorium* which has invaded the moister forested regions, Mysore Plateau. (Photo: *H. C. Sharatchandra*).

nopy, palatable herbage can grow on the floor of the forest. The much larger younger crop of saplings produced would also provide browsing. Such degraded forest does therefore become a better habitat for larger mammalian herbivores.

Sholas and Downs

The higher reaches of the Western Ghats are characterized by a juxtaposition of evergreen sholas lying in the hollows and grassy downs on the more exposed slopes. These grassy downs offer rich grazing grounds for the larger mammals, while the evergreen sholas provide them good shelter. The combination therefore affords an ideal habitat for a rich variety of mammalian species (See Plate 1).

Deciduous Forests

The deciduous forests offer a much more balanced picture of the availability of food resources for the mammalian species. In such vegetation, the total amount of tree foliage and fleshy fruits will be less than in the evergreen forests, rendering it a somewhat less suitable habitat for frugivorous monkeys and squirrels. At the same time, the more open canopy will allow growth of grass and other palatable herbage and shrubbery on the forest floor, as well as a rich growth of bamboos rendering it a much more suitable habitat for the larger herbivores such as deer, gaur and elephant (See Plate 2). Moderate degradation of such forest further encourages the growth of grass and bamboo, improving it as a habitat for larger mammals. As will be noted from Tables 1, 2 and 3, the deciduous forests are an excellent habitat for a wide spectrum of mammals.

This is not to imply that indefinite degradation of deciduous forests will progressively improve them as wild life habitats. Such forests are quickly invaded by *Lantana* and *Eupatorium*, the former favouring dry deciduous and the latter moist deciduous habitats. *Lantana* though largely unpalatable to wild mammals, does provide fresh leaves, flowers and berries which are consumed. The berries are a favourite food of birds as well. *Eupatorium*, on the other hand, has no redeeming features. It carpets vast stretches of forest floor, smothering out all regeneration, posing a fire hazard, and is absolutely unpalatable to wild animals who never touch it (See Plate 2).

Scrub Forests

The scrub forest in its climax condition is overall a less productive habitat than the degraded deciduous forest. The *Acacias* which dominate it are nevertheless a good source of palatable leaves and pods for many browsing herbivores, particularly elephants. Under its natural condition, the scrub forest can therefore support a rich mammalian fauna as indicated in Tables 1, 2 and 3. An important limiting factor in these forests is water. Since antelopes such as blackbuck and nilgai are much more tolerant of drought than deer and gaur they tend to dominate the community of grazing herbivores in such habitats.

A degraded scrub is reduced to a secondary grassland of very poor productivity (See Plate 3). Such habitat can essentially support only blackbuck and chinkara and smaller mammals such as hares.

Carnivores

Table 4 summarizes the expected pattern of natural abundance of carnivores in different vegetation types. Stalking predators such as tiger and panther require a good population of larger mammals plus good cover. They are therefore at their best in deciduous forests. Cheetah which depends on speed for pursuit requires more open country and was once common in scrub forests of India but is now extinct. The wild dogs and wolves depend on their stamina, teamwork and speed to run down their quarry. The former seems more adapted to forest habitat and the latter to open scrub.

Tables 3 and 4 thus summarize the pattern of distribution of wild mammals that should prevail in peninsular India in the absence of a serious persecution of these animals at the hand of man. Some species, such as elephant and wild pig would be rather widely distributed, while others such as lion-tailed macaque would be much more restricted in their distribution. Nevertheless there would be an overall high abundance of wild mammals throughout the variety of wild habitats. This supposition is supported by the available historical evidence, particularly recorded in the early gazetteers. (Nicholson 1887, Stuart 1895, Francis 1904, Anonymous 1908). No more than a century ago, a variety of wild mammals occurred commonly throughout much of the state of Karnataka largely conforming to the pattern indicated in Tables 3 and 4.

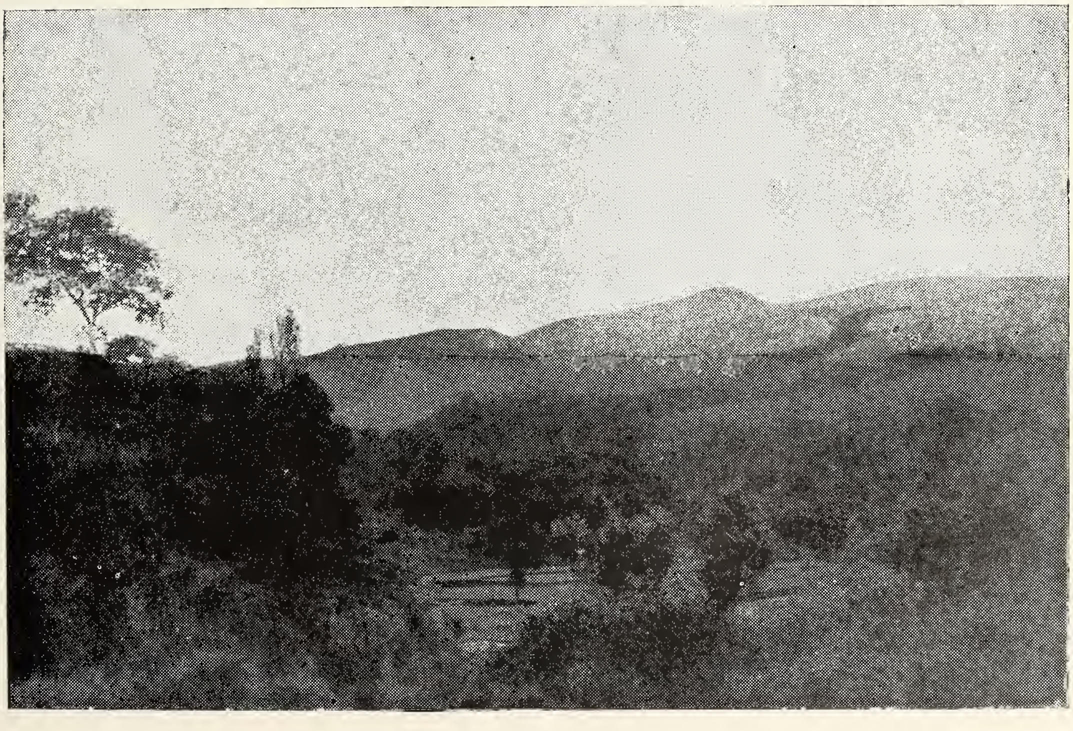
There were of course tracts which had been under intensive cultivation for a long time, and from which wild mammals were largely excluded. Such, for example must have been the case with paddy lands in the coastal plains of South Kanara. There were however still vast tracts of lands under natural vegetation, and with large mammalian populations till a century ago, their abundance essentially governed by the availability of resources required by each of the various species in different types of natural vegetation. The last century in particular has seen rapid changes and overall drastic decline in the populations of wild mammals of Karnataka due to mounting pressures of persecution by man.

HUMAN PERSECUTION

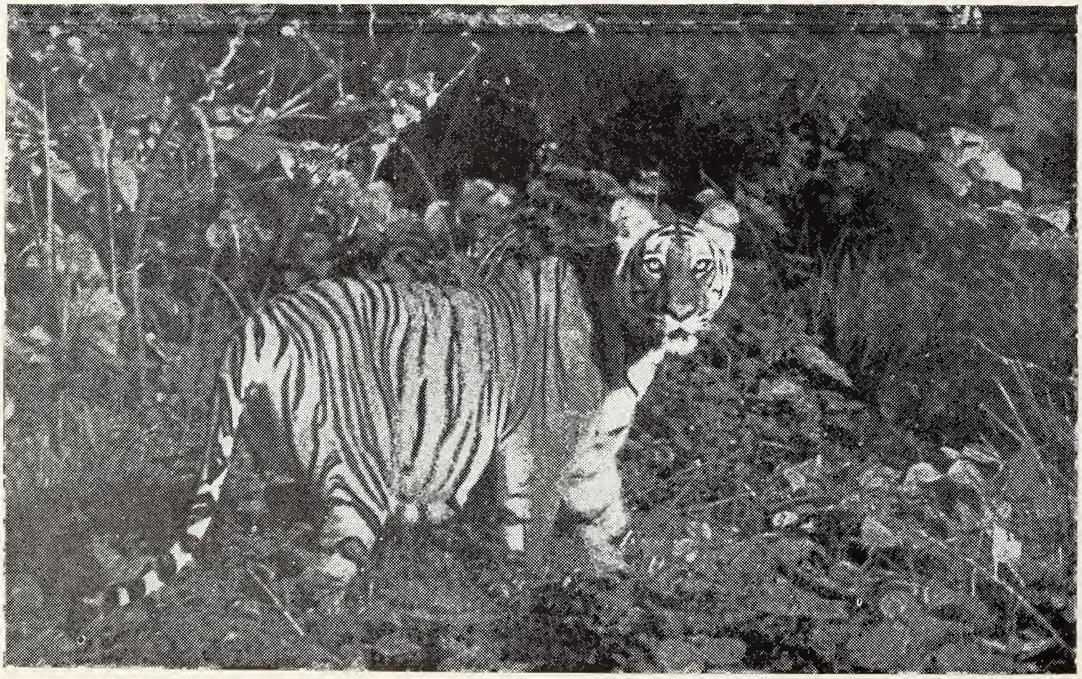
The degree to which the persecution by man has affected the mammalian fauna has varied considerably in different habitats and for different species depending on a variety of factors. These factors include (1) accessibility of wild life habitats to man (2) ease of hunting a species (3) reproductive resiliency of the species (4) religious protection enjoyed by a species (5) commercial demand for trophy, presumed medicinal value etc. (6) conflicts with human interests because of crop raiding, killing of livestock etc. (7) extent of demand for the habitat of wild animals such as for mining.

It may be worthwhile reviewing the effect of human persecution on the twentytwo major wild mammals of Karnataka listed in Tables 3 and 4. The lion-tailed macaque has always been restricted to a few pockets of evergreen vegetation. Its habitat is rapidly diminishing and degrading, and this rare, essentially frugivorous, primate is an endangered species. The bonnet macaque enjoys wide religious protection and still lives in large populations throughout the state in forests, scrub as well as in cultivated tracts. The hanuman langur is a more specialized leaf eating monkey, and has a more restricted distribution than the omnivorous bonnet macaque. It also enjoys religious protection and lives in good numbers in deciduous forest tracts. The giant squirrel is essentially restricted to evergreen, semi-evergreen and moist deciduous forests where it occurs in good numbers.

The elephant populations have suffered drastically through loss and fragmentation of habitat, persecution for ivory and killing for crop protection. A good population nevertheless exists in the Bandipur-Nagarhole complex (Nair and Gadgil, in press). Gaur are still widely distributed, particularly in deciduous forests,



Above: A view of the scrub forest in the Kollegal Hills Region.
Below: Cultivation in the midst of forest, Haliyal Division in North Kanara region. (Photos: *P. V. K. Nair*).



Above: An elephant herd in Bandipur Tiger Reserve.
Below: A tiger in Bandipur Tiger Reserve. (Photos: *A. J. T. Johnsingh*).

though much reduced in numbers due to poaching for meat and hide. Sambar very much follow the pattern of gaur. Chital are restricted to more open degraded deciduous forests, where they survive in good numbers where protected. Barking deer, a solitary species with wide habitat tolerance is much hunted for meat and survives in thin populations.

Blackbuck, chinkara, nilgai, wolves and cheetah once inhabited the open scrub forests in large numbers. Living in accessible plains, easily hunted in their open habitat, they have been the main victims of persecution at the hand of man. Cheetah has become totally extinct and the others have nearly disappeared too, surviving only in small pockets where they are given special protection.

Blacknaped hare, wild pig and jackal are the only three species still surviving in good numbers. This is due to their ability to take advantage of man-made habitats and cultivation, and their great reproductive resilience. All three breed in sheltered places and produce moderate to large litters. This has enabled them to minimise persecution, and to rapidly build up their populations in face of persecution.

Porcupine, a solitary nocturnal animal is hunted for meat with the help of dogs who locate their burrows. It nevertheless survives in scattered populations. The omnivorous sloth bear, a denizen of evergreen—deciduous forests, is not particularly persecuted, and probably survives in scattered populations.

Of the carnivores, tiger, panther and wild dog are all much persecuted, the first two for their valuable pelt and to avenge cattle kills, and the third rather wantonly, even by the official foresters as a competitor for herbivores with man. The first two have declined drastically, while the wild dog seems to be holding its own much better.

PRESENT STATUS

The area under forest in Karnataka today amounts to 28846 sq. kms, a mere 15.04% of the total land area of the state. With the notable exception of the bonnet macaque, which under the widespread religious protection ranges throughout the state, the larger wild mammals are entirely confined to the forest areas. These forest areas, may, for our purpose be divided into six different regions, each of which is largely contiguous and has distinctive ecological features. For convenience, we have named these six wildlife regions: North Kanara, Crestline, Malnad, Mysore Plateau, Kollegal Hills and Maidan (Fig. 1) (Nair & Gadgil, in press).

North Kanara

The district of North Kanara and parts of Belgaum constitute the northernmost sector of hill tracts of Karnataka (latitude 13°45′N to 15°45′N, longitude 75°0′ E to 75°15′ E). The hills are low, but form a rather wide belt. The precipitation varies from 6500 mm at the crest to about 1000 mm on the plateau, and the vegetation consequently ranges from evergreen, semi-evergreen, moist deciduous to dry deciduous types. The proportion of deciduous forest computed as the proportion of forest ranges predominantly deciduous in nature, is 0.52. At one time, over 80% of this region was under forest cover. It has been, however, considerably disturbed in recent years with rapidly multiplying human settlements, heavy exploitation of forest for timber and softwoods and bamboo, manganese and iron mining, and aboveall the giant Kalinadi hydel project. Consequently, the habitat is now very much fragmented, with the index of habitat fragmentation at a high value of 0.92 (See Plate 3).

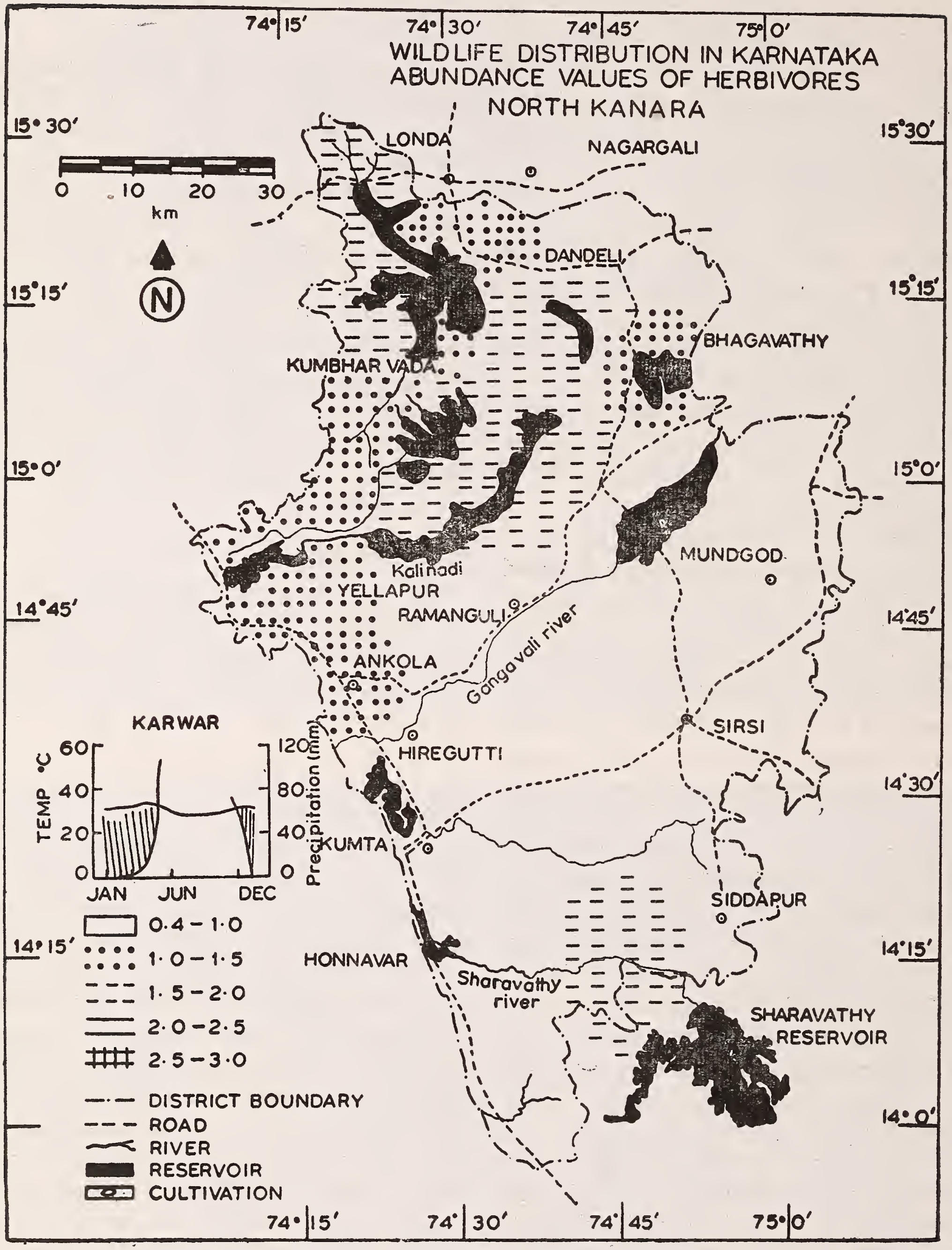

WILDLIFE DISTRIBUTION IN KARNATAKA
ABUNDANCE VALUES OF HERBIVORES
NORTH KANARA
74° 15′
74° 30′
74° 45′
75° 0′
15° 30′
15° 15′
15° 0′
14° 45′
14° 30′
14° 15′
14° 0′
0 10 20 30
km
N
LONDA
NAGARGALI
DANDELI
BHAGAVATHY
KUMBHAR VADA
Kalinadi
YELLAPUR
RAMANGULI
Gangavali river
MUNDGOD
ANKOLA
HIREGUTTI
SIRSI
KUMTA
SIDDAPUR
HONNAVAR
Sharavathy river
SHARAVATHY RESERVOIR
KARWAR
TEMP °C
60
40
20
0
Precipitation (mm)
120
80
40
0
JAN
JUN
DEC
0·4 – 1·0
1·0 – 1·5
1·5 – 2·0
2·0 – 2·5
2·5 – 3·0
DISTRICT BOUNDARY
ROAD
RIVER
RESERVOIR
CULTIVATION

Fig. 3. A map of North Kanara region indicating the occurrence rating of larger mammalian herbivores.

Table 7 lists the occurrence rating for 8 of the major wild mammals of this region over 26 ranges. The data are further summarised in tables 5 and 6 and figure 3. There are today only five small herds of elephants over this vast forested region, scattered in the semi-evergreen and moist deciduous tracts. They cover two-thirds of the ranges of the region. The frequency of incidence of gaur is similar, and it also occurs in small scattered herds with larger herds surviving only in parts of Haliyal division. Sambar is much more widely distributed, occurring in 85% of the ranges, barring the heavier rainfall areas. It also receives a little better occurrence ranking. The spotted deer occurs in little over half the ranges and is in low abundance. This thick, moist forest is obviously a poor habitat for it. The wild pig occurs over almost all ranges and is the most abundant of wild mammals. Its tolerance of a wide range of vegetation types, its penchant for crop raiding, and its high reproductive rate are the reasons for its greater success. Evergreen forests of North Kanara harbour some populations of lion-tailed macaque in the Siddapur Range. The hanuman langur is commonly found particularly in the semi-evergreen and moist deciduous tracts. The carnivores, tiger, panther and wild dog all occur in rather low populations but are distributed over many of the ranges. They are commoner in the dry deciduous ranges of Katur, Mundgod and Kirwatti, and quite uncommon in the evergreen forest.

The great forests of North Kanara are a little too dominated by evergreen and semi-evergreen types to be an optimal habitat for larger wild mammals. However, its deciduous forests too are very extensive and rich in bamboo—a prime fodder for large herbivores. The very high frequencies of incidence coupled with the low abundances suggest that the wild mammal populations have been decimated everywhere through human persecution. The high value of habitat fragmentation bears out this supposition of rather extensive human influence on the wild life.

Crestline

To the south of North Kanara, the Western Ghats rise much higher, and narrower. The rainfall in this region is very heavy reaching 6000 - 7000 mm. There is a rather narrow belt of forests following this crestline of the ghats (latitude 11°30′ N to 14°0′ N, longitude 74°15′ E to 76°30′ E). The vegetation is evergreen on the steep slopes west of the crestline. There is a belt of semi-evergreen and moist deciduous forests at the foothills on the west, as well as on the eastern slopes. The proportion of deciduous forests is 0.27, and the fragmentation index is 0.57.

Table 7 lists the occurrence rating for wild animals in 21 of the forest ranges of this region, while tables 5 and 6 and figure 4 summarise the data. As may be seen from these, the wild mammal populations are on the whole very poor, although most of the major species do occur in this region. Only a few isolated herds of elephants are found in these evergreen forests, and even these have perhaps been forced out by the deforestation of the deciduous tracts to the east of the crestline. The gaur and sambar have high frequencies of incidence (85% each), but occur commonly only on the foot hills of Coondapur. The spotted deer occurs only very sporadically and in low numbers. The wild pig, however, is present in all ranges, and is often quite common. Again its adaptibility to evergreen forests, to crop raiding, and its high reproductive rate render it the most successful of larger wild mammals. The lion-tailed macaque occurs in the evergreen forests of Sagar.

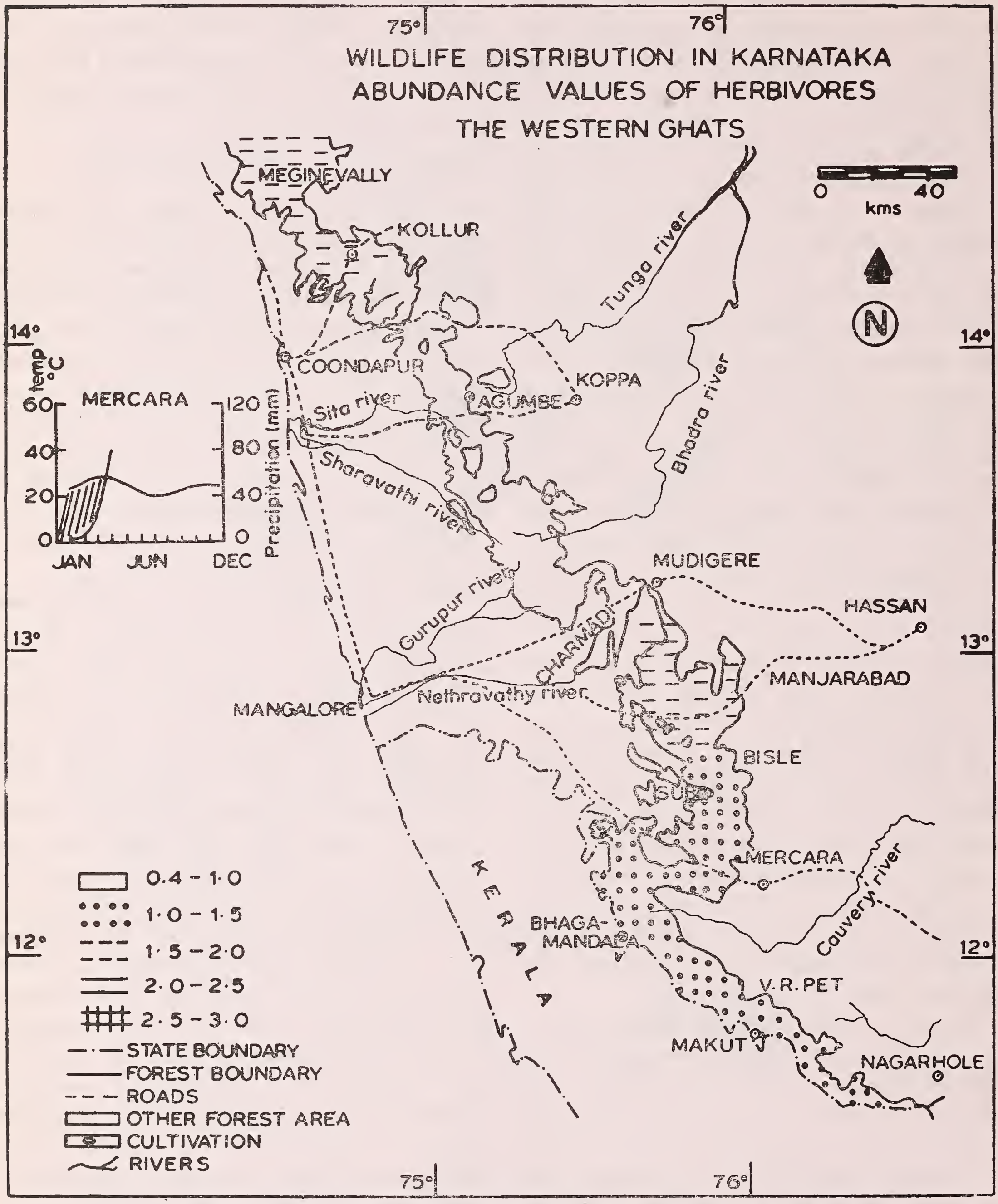

WILDLIFE DISTRIBUTION IN KARNATAKA
ABUNDANCE VALUES OF HERBIVORES
THE WESTERN GHATS
75°
76°
14°
13°
12°
0
40
kms
N
MEGINEVALLY
KOLLUR
COONDAPUR
KOPPA
AGUMBE
Tunga river
Bhadra river
Sita river
Sharavathi river
Gurupur river
CHARMADI
Nethravathy river
MUDIGERE
HASSAN
MANJARABAD
MANGALORE
BISLE
SUBR
MERCARA
Cauvery river
BHAGA-MANDALA
V.R.PET
MAKUT
NAGARHOLE
KERALA
MERCARA
temp °C
60
40
20
0
JAN
JUN
DEC
120
80
40
0
Precipitation (mm)
0.4 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
STATE BOUNDARY
FOREST BOUNDARY
ROADS
OTHER FOREST AREA
CULTIVATION
RIVERS

Fig. 4. A map of Crestline region indicating the occurrence rating of large mammalian herbivores.

The hanuman langur is present as well. The carnivores, tiger, panther and wild dog are all present, but their occurrence rating is low in conformity with the low occurrence rating of their prey.

Only a small proportion, 0.27, of the surviving forests in the region of the crestline are deciduous. As discussed above, this implies a poor habitat for most large herbivores, and consequently for carnivores. This is probably an important factor in the very low occurrence ratings of all the major mammals except the wild pig. At the same time, the evergreen forests provide the habitat for a most interesting primate—the lion-tailed macaque. There are in this region some tracts of interspersion of evergreen sholas and grassy downs which provide excellent habitats for many mammals such as gaur and sambar. The low abundances must then also relate to considerable human persecution. This is the case, even though the fragmentation index is relatively low, because the forests occur in a rather narrow linear strip.

Malnad

This region lies to the east of the crestline, seperated by a wide belt of coffee and cultivation (13° 0′ N to 14° 15′ N lat. and 75° 0′ E to 76° 0′ E long.). The area, albeit rather plain, owes its forest cover to several large hills like the Shankar hills and the Bababudangiris rising out of the plains. The rainfall is around 1000 mm, and there are extensive tracts of dry and moist deciduous forest. The proportion of deciduous forests is 0.64, and the fragmentation of the habitat is on the low side, the index taking a value of 0.64.

We have estimates of occurrence ratings of major mammalian species in 14 of the forest ranges of Malnad region; and it is evident that this region boasts of wild life populations only second to Mysore plateau (Tables 5,6 and fig. 5). Almost all of the ranges support elephant populations with a rather large herd of 30-40 living by the Bhadra reservoir. The gaur also occur extensively, being present over 76% of the ranges. The sambar is present in almost all the ranges, as is spotted deer which finds its optimum habitat in the rather degraded deciduous forests of this region. Wild pig, as in other regions is ubiquitous. There are no lion-tailed macaques in the absence of habitable evergreen tracts which are all taken up by coffee plantations, but the hanuman langur is common throughout. The wild dog, panther and tiger are present over most of the region, and their overall occurrence is also high in concert with the higher populations of herbivores.

Overall, the Malnad region, with its opened up deciduous forests is potentially an outstanding wild life habitat. The tracts of forest in this region are extensive with relatively little human interference in the deeper forests. The extensive coffee plantations, heavy exploitation of the forest by forest-based industries, particularly the paper mills, and the disturbance caused by the construction of Tunga and Bhadra reservoirs have however largely decimated the wild life populations which today are a pale shadow of their former self.

Mysore Plateau

The western edge of the Mysore Plateau, flanked on three sides by the southernmost ranges of Sahyadris proper, Nilgiris and the eastern spur of hills towards Biligirirangans is an undulating plain with a rainfall between 600 to 1000 mm a year (lat. 11°35′N and 12° 45′N and long. 75° 54′ E and 77° 0′ E). The plateau is covered by moist and dry deciduous

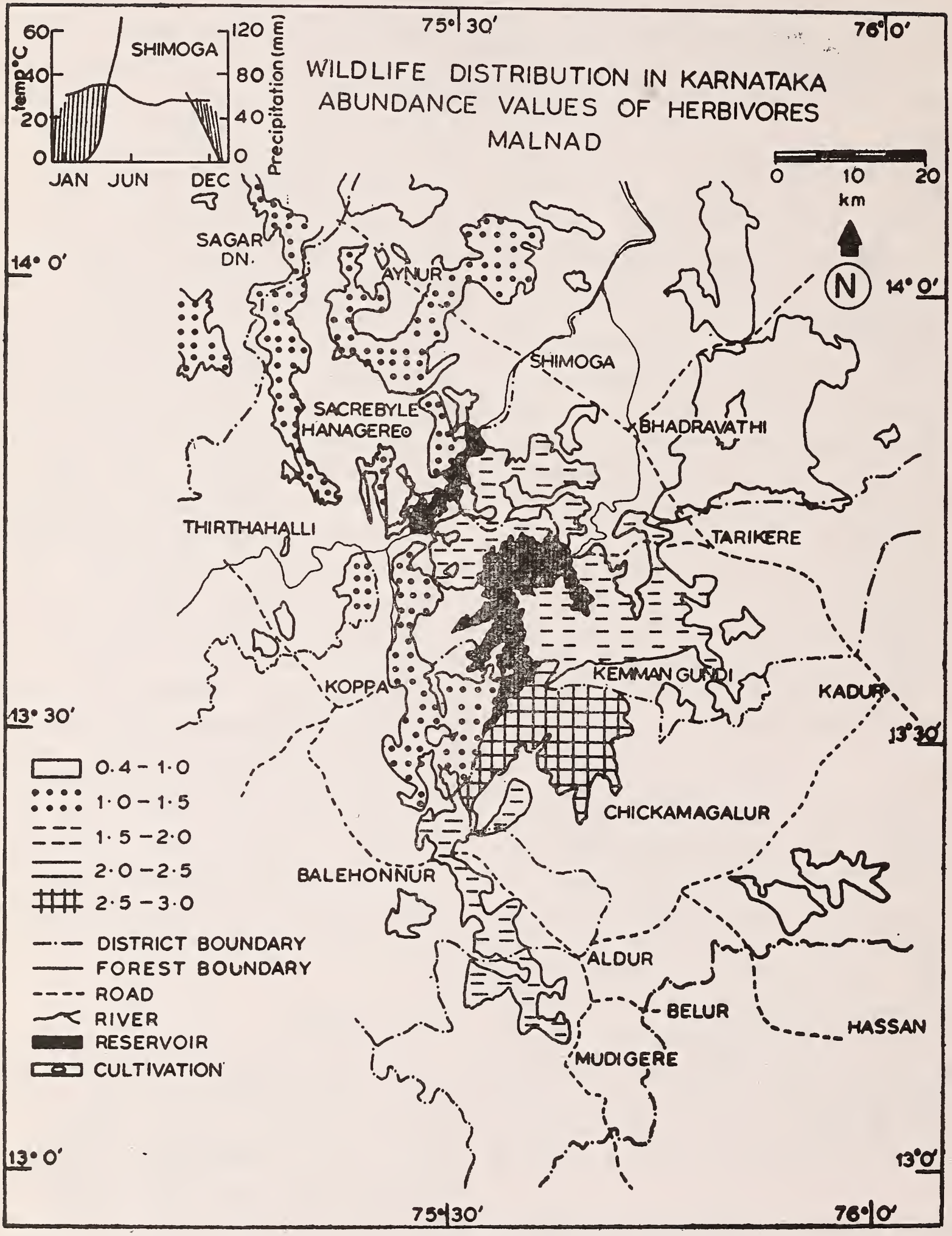

WILDLIFE DISTRIBUTION IN KARNATAKA
ABUNDANCE VALUES OF HERBIVORES
MALNAD
SHIMOGA
temp °C
Precipitation (mm)
60
40
20
0
120
80
40
0
JAN
JUN
DEC
75° 30′
76° 0′
14° 0′
13° 30′
13° 0′
0
10
20
km
N
SAGAR DN.
AYNUR
SHIMOGA
BHADRAVATHI
SACREBYLE
HANAGERE
THIRTHAHALLI
TARIKERE
KOPPA
KEMMAN GUNDI
KADUR
CHICKAMAGALUR
BALEHONNUR
ALDUR
BELUR
HASSAN
MUDIGERE
0.4 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
DISTRICT BOUNDARY
FOREST BOUNDARY
ROAD
RIVER
RESERVOIR
CULTIVATION

Fig. 5. A map of the Malnad region indicating the occurrence rating of larger mammalian herbivores.

forests, the proportion of the deciduous forests being 1. The forest still maintains much of its integrity though now split into two by the Kabini reservoir, and the fragmentations index of 0.70 is relatively low.

This is undoubtedly the richest wild life region in the state and has been the subject of an earlier detailed report by us (Nair *et al.* 1977). Table 7 lists the occurrence rating for mammals for 13 forest ranges falling within this region, and Tables 5 and 6 and Fig. 6 summarize the data. It is the only region where certain wild mammals can still be considered to be abundant, albeit locally. It has an elephant population of about 1300 animals, a gaur population which was very high till a rinderpest outbreak in 1968, a sambar and a chital population very good in pockets, a good wild pig population, and a good population of hanuman langur. The carnivores too are reasonably common, particularly wild dogs. Panthers and tigers also survive in reasonable numbers (See Plates 4 and 5).

The richness of this wild mammal fauna depends on the eminent suitability of the habitat, which is entirely somewhat degraded deciduous forest, and the protection from persecution over much of the region first as a hunting preserve of Mysore maharaja and then as wild life sanctuaries.

Kollegal Hills

This hilly area, lying between 11° 30′ and 13° 0′N latitude and 77° 15′ and 77° 45′ E longitude is an eastern spur of the ghats. The rainfall is low, around 500 mm except on the Biligirirangan hills where it exceeds 1000 mm. Apart from the moist deciduous, or semi-evergreen forest on these hills, the rest of the region is covered by dry deciduous forest, mostly degraded into scrub. The proximity of the urban centre of Bangalore has been a major factor in hastening the pace of degradation of these forests. Because of this degradation, the proportion of deciduous forests is low—only 0.4, and the forests are highly fragmented, with a fragmentation index of 0.71.

Table 7 presents larger wild mammal occurrence ratings for 10 ranges of this region (See figure 7). Elephants occur over most of this region, and this highly adaptable species still maintains a good population in this and the adjacent Satyamangalam forests. The gaur is restricted to areas where the forest remains at the dry deciduous stage. Spotted deer, sambar and wild pig occur throughout all the ranges. The opened deciduous forest is of course a good habitat for the deer, but the persistence o fthe pig from evergreen to scrub speaks for its versatility. The wild dogs have a fairly extensive distribution, though panther and tiger are much more restricted.

Earlier accounts indicate that this was once a quite rich wild life area in spite of the dryness of the climatic regime. The current rather low occurrence ratings are due to further degradation of the vegetation, and persecution by man in this highly fragmented habitat.

Maidan

Most of the forests of Karnataka, as mentioned earlier, clothe the hills of the Western Ghats, or the adjoining hills in Chickmagalur —Shimoga and Kollegal regions. There is very little forest on the remaining maidan areas on the Deccan Plateau, and what there is of such forest is highly degraded, fragmented and practically devoid of any wild mammals. The proportion of deciduous forest in this region is 0 while the fragmentation index takes the value of 1.

One single range in this region, that of Ranebennur is however notable for the occurrence of good herds of blackbuck, and re-

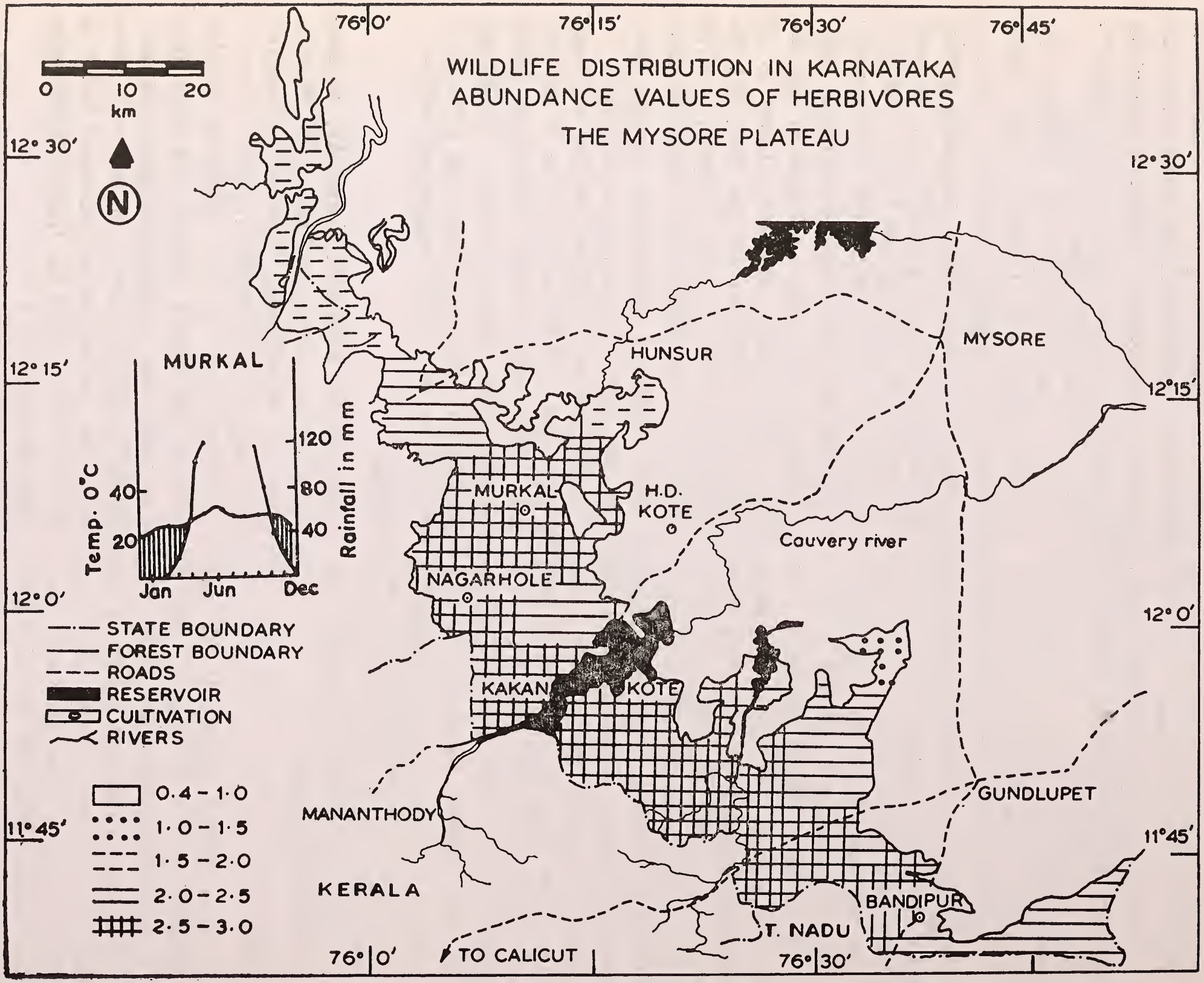
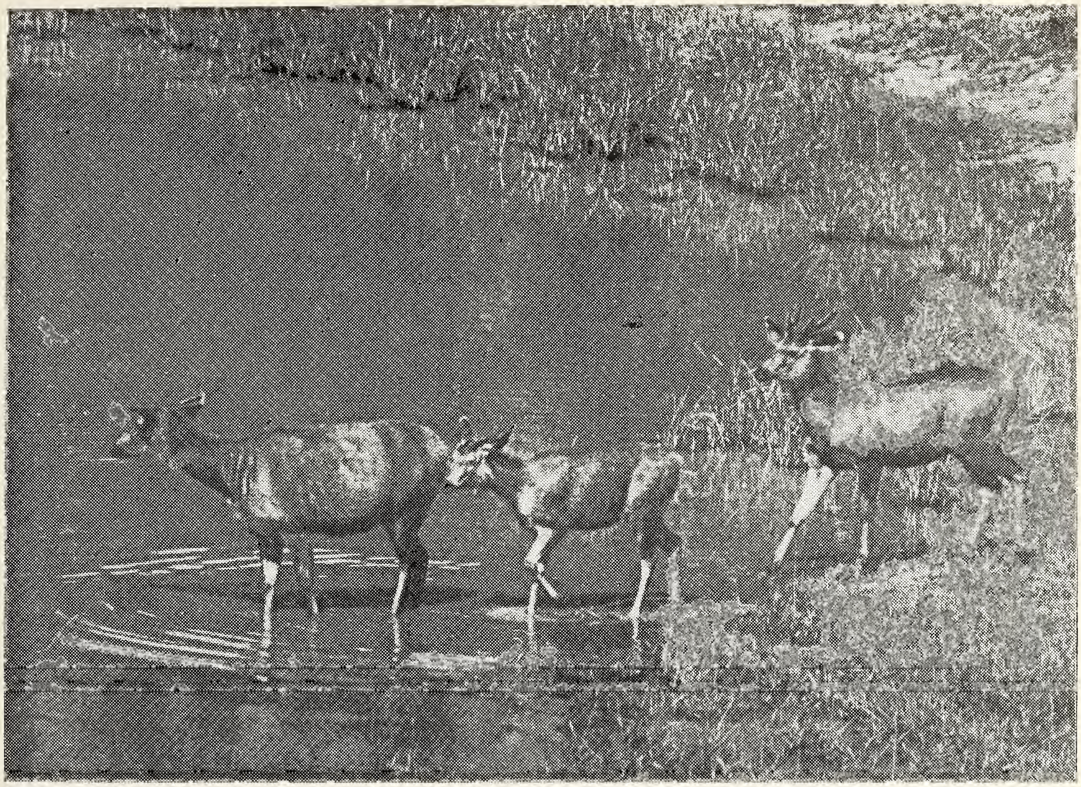

WILDLIFE DISTRIBUTION IN KARNATAKA
ABUNDANCE VALUES OF HERBIVORES
THE MYSORE PLATEAU
76°0'
76°15'
76°30'
76°45'
12°30'
12°15'
12°0'
11°45'
0
10
20
km
N
MURKAL
Temp. 0°C
40
20
120
80
40
Rainfall in mm
Jan
Jun
Dec
STATE BOUNDARY
FOREST BOUNDARY
ROADS
RESERVOIR
CULTIVATION
RIVERS
0.4 – 1.0
1.0 – 1.5
1.5 – 2.0
2.0 – 2.5
2.5 – 3.0
HUNSUR
MYSORE
MURKAL
H.D. KOTE
Cauvery river
NAGARHOLE
KAKAN
KOTE
MANANTHODY
KERALA
GUNDLUPET
BANDIPUR
T. NADU
TO CALICUT

Fig. 6. A map of the Mysore plateau indicating the occurrence rating of larger mammalian herbivores.



Above: Sambar in Bandipur Tiger Reserve. (Photo: *A. J. T. Johnsingh*).
Below: A view of the Ranebennur plains with *Eucalyptus* plantations in the background. (Photo: *S. N. Prasad*).

portedly a few wolves in the Ranebennur sanctuary. This herd apparently built up from a few blackbuck which received protection when a *Eucalyptus* plantation was started in the degraded forest of this range (Neginhal, in press) (See plate 5). Such scattered remnants of blackbuck also apparently occur in other areas such as Raichur.

Much of this dry and open country once supported good populations of antelopes—blackbuck, chinkara and nilgai which have vanished because of the ease of hunting in the habitats of these animals. As stressed earlier, this fauna of open scrubby plains has suffered the worst at the hand of man, with cheetah extinct, and wolf and blackbuck threatened with extinction.

CONCLUSION

It is perhaps worth commenting on a few of the significant points which emerge out of this analysis. The maintenance of the integrity of the habitat is critical to all our attempts at nature conservation. The great decimation of wild life in North Kanara in particular is largely due to the extreme fragmentation of this great forest, and a similar phenomenon repeats itself in other regions of the state. Apart from this immediately evident effect, much evidence is now accumulating from a number of ecological studies to show that small, fragmented habitats cannot in the long run sustain their original biological diversity, though they may continue to do so in the short run. It is therefore being stressed that maintenance of large contiguous areas should be a very important aim of all efforts at designing nature reserves (Diamond 1975). We must therefore strive to avoid any further fragmentation of the wild life habitats, particularly in the few viable areas such as the Bandipur—Nagarhole complex which still remain with us.

The second point that emerges is that the situation is far worse in respect of the conservation of the fauna of the evergreen forests and scrub when compared with that of the fauna of the deciduous forest. As investigations of Dr. Pascal and his colleagues from the French Institute have shown, very little now remains of the once extensive evergreen forests on the Western Ghats of Karnataka. The one larger mammal—the lion-tailed macaque—characteristic of the evergreen forests of South India is thereby threatened with extinction. Much more importantly, a large number of amphibians and reptiles which are also unique to this ecosystem are no doubt likewise disappearing, although this is hardly realised because of our near-total ignorance of this fauna.

As emphasized above, the fauna of the open scrub has been decimated to a much greater degree than that of the thicker forests, and there is an urgency to step up efforts to conserve and replenish it. There are no sanctuaries representing this type of ecosystem in Karnataka, except for Ranebennur. Ranebennur is however a *Eucalyptus* plantation and as Neginhal (in press) has shown, is fast losing its ability to sustain the blackbuck population. It is imperative that a genuine scrub vegetation be built up, its typical wild life restocked and the ecosystem restored in some reasonably large wild life sanctuary in the semi-arid belt of the Deccan plateau.

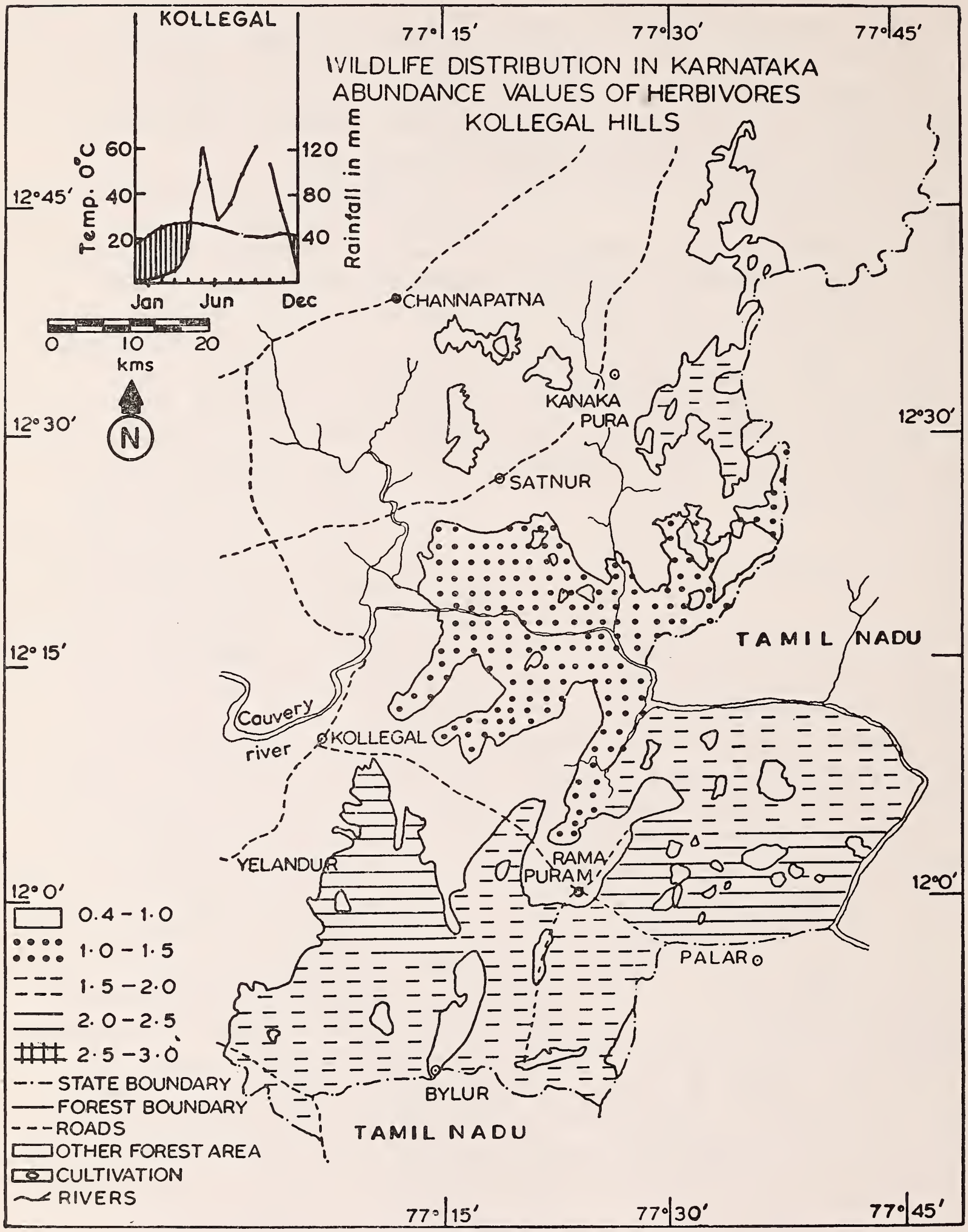

WILDLIFE DISTRIBUTION IN KARNATAKA
ABUNDANCE VALUES OF HERBIVORES
KOLLEGAL HILLS
KOLLEGAL
Temp. 0°C
60
40
20
Rainfall in mm
120
80
40
Jan
Jun
Dec
0
10
20
kms
N
77° 15'
77° 30'
77° 45'
12°45'
12°30'
12° 15'
12° 0'
12°30'
12°0'
CHANNAPATNA
KANAKA PURA
SATNUR
TAMIL NADU
Cauvery river
KOLLEGAL
YELANDUR
RAMA PURAM
PALAR
BYLUR
TAMIL NADU
0.4 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
STATE BOUNDARY
FOREST BOUNDARY
ROADS
OTHER FOREST AREA
CULTIVATION
RIVERS

Fig. 7. A map of the Kollegal Hills indicating the occurrence rating of larger mammalian herbivores.

TABLE 1

ON THE DISTRIBUTION OF FOOD RESOURCES OF MAMMALIAN POPULATIONS IN DIFFERENT TYPES OF VEGETATION

	Grass	Herbs	Shrubs	Bamboo	Tree leaves	Woody matter	Fleshy fruits	Seeds	Tubers	Insects	Frogs & lizards
Evergreen											
Climax	O	R	R	O	A	A	A	R	R	A	A
Degraded	C	C	C	C	A	A	A	C	C	A	A
Shola and grassy downs	A	R	R	O	A	A	A	A	R	A	A
Deciduous											
Climax	R	C	C	C	A	A	A	A	C	A	A
Degraded	A	A	A	A	A	A	A	A	C	A	C
Scrub											
Climax	C	C	A	O	C	C	C	C	R	C	C
Degraded	C	C	C	O	R	R	R	C	R	C	C

O = absent, R = Rare, C = Common, A = Abundant.

TABLE 2

ON THE DEPENDENCE OF HERBIVOROUS OR OMNIVOROUS MAMMALS ON DIFFERENT FOOD RESOURCES

	Grass	Herbs	Shrubs	Bamboo	Tree leaves	Woody matter	Fleshy fruits	Seeds	Tubers	Insects	Frogs & lizards
Liontailed Macaque	R	O	O	O	R	O	A	R	O	C	O
Bonnet Macaque	O	R	R	C	O	R	C	C	O	C	R
Hanuman Langur	O	C	A	A	A	O	A	C	O	O	O
Giant Squirrel	O	O	O	O	R	C	A	A	O	C	O
Elephant	A	C	R	A	C	C	C	R	O	O	O
Gaur	A	R	C	C	R	O	C	O	O	O	O
Sambar	A	R	A	C	R	O	C	O	O	O	O
Chital	A	R	C	C	R	O	C	O	O	O	O
Barking Deer	A	R	R	C	R	O	C	O	O	O	O
Nilgai	A	R	C	C	R	O	O	O	O	O	O
Blackbuck	A	R	C	O	O	O	C	R	O	O	O
Chinkara	A	R	C	O	O	O	C	O	O	O	O
Nilgiri Tahr	A	R	O	O	O	O	O	O	O	O	O
Wild Pig	R	R	R	C	O	O	C	C	A	C	C
Blacknaped Hare	A	C	R	R	O	O	O	O	O	O	O
Porcupine	O	O	C	C	O	C	A	C	A	R	O
Other Rodents	R	R	R	C	R	C	C	A	A	A	O
Sloth Bear	O	O	O	O	O	O	A	R	A	A	R

O = absent, R = Rare, C = Common, A = Abundant.

TABLE 3

DISTRIBUTION OF HERBIVOROUS OR OMNIVOROUS MAMMALS IN DIFFERENT VEGETATION TYPES WHEN UNDISTURBED.

	Evergreen		Shola and grassy downs	Deciduous		Scrub	
	Climax	Degraded		Climax	Degraded	Climax	Degraded
Lion-tailed Macaque	A	C	A*	O	O	O	O
Bonnet Macaque	O	R	O	C	C	C	C
Hanuman Langur	R	R	R	A	A	C	R
Giant Squirrel	A	A	A	A	C	O	O
Elephant	R	C	C	A	A	C	R
Gaur	R	C	A	A	A	R	O
Sambar	R	C	A	A	A	C	R
Nilgai	O	O	O	C	C	A	R
Chital	O	O	O	C	A	C	R
Barking Deer	O	R	R	C	C	C	C
Blackbuck	O	O	O	O	O	A	C
Chinkara	O	O	O	O	O	A	C
Nilgiri Tahr	O	O	A	O	O	O	O
Wild Pig	R	C	C	A	A	R	R
Blacknaped Hare	O	O	C	C	A	A	A
Porcupine	R	C	C	A	A	C	O
Rodents	C	C	C	C	A	A	A
Sloth Bear	R	C	C	A	C	R	R

*Shola only. O = Absent, R = Rare, C = Common, and A = Abundant

TABLE 4

DISTRIBUTION OF CARNIVOROUS MAMMALS IN DIFFERENT VEGETATION TYPES, GIVEN THAT THERE IS NO HUNTING PRESSURE, AND HERBIVORES ARE PRESENT IN KINDS OF ABUNDANCES INDICATED IN TABLE 3.

	Evergreen		Shola & downs	Deciduous		Scrub	
	Climax	Degraded		Climax	Degraded	Climax	Degraded
Jackal	O	O	C	R	A	A	A
Wolf	O	O	O	O	C	A	A
Cheetah*	O	O	O	O	R	A	A
Wild Dog	O	C	A	A	A	A	O
Panther	R	C	A	A	A	C	O
Tiger	R	C	A	A	C	O	O

O = Absent, R = Rare, C = Common, A = Abundant.

* Now extinct in India.

TABLE 5

THE PROPORTION OF FOREST RANGES CONTAINING DECIDUOUS FOREST, THE INDEX OF HABITAT FRAGMENTATION, AND AVERAGE OCCURRENCE RATING FOR HERBIVORES AND CARNIVORES FOR THE SIX DIFFERENT WILD LIFE BEARING REGIONS OF THE STATE.

Region	Proportion Deciduous	Fragmentation Index	Herbivore occurrence	Carnivore occurrence
North Kanara	0.52	0.92	1.38	0.81
Crestline	0.27	0.57	1.09	0.66
Malnad	0.64	0.64	1.91	0.80
Mysore Plateau	1.00	0.7	2.61	2.00
Kollegal Hills	0.4	0.71	1.72	0.76
Maidan	0	1.0	0.32	0.04

TABLE 6

AVERAGE OCCURRENCE RATING AND FREQUENCY OF INCIDENCE FOR THE MAJOR MAMMALIAN SPECIES IN THE SIX REGIONS OF KARNATAKA.

Name of the area	Elephant	Gaur	Sambar	Spotted Deer	Wild Pig	Wild Dog	Panther	Tiger	Black buck
1. *North Kanara*									
Frequency	65	70	85	58	100	35	65	65	—
Occurrence rating	1.23	1.0	1.38	0.86	1.80	0.50	0.50	0.50	—
2. *Crestline*									
Frequency	57	85	85	20	100	35	45	45	—
Occurrence rating	1.00	0.90	0.90	0.26	1.55	0.42	0.47	0.47	—
3. *Malnad*									
Frequency	92	76	100	92	100	64	50	76	—
Occurrence rating	1.78	1.64	2.14	1.65	2.14	0.92	0.64	0.92	—
4. *Mysore Plateau*									
Frequency	100	100	100	100	100	100	100	100	—
Occurrence rating	3.23	2.07	2.53	2.61	2.61	2.58	2.07	1.00	—
5. *Kollegal Hills*									
Frequency	100	50	100	100	90	70	40	50	—
Occurrence rating	2.1	1.00	1.9	1.8	1.3	1.2	0.40	0.60	—
6. *Maidan*									
Frequency	—	—	—	—	—	—	—	—	4
Occurrence rating	—	—	—	—	—	—	—	—	—

TABLE 7

DISTRIBUTION OF LARGER MAMMALS IN THE FOREST RANGES OF KARNATAKA

Sl. No.	Name of range	Elephant	Gaur	Spotted deer	Sambar	Wild pig	Wild dog	Panther	Tiger
Area No. 1—**North Kanara**									
1	Londa	3	–	–	2	2	0	–	–
2	Khanapur	2	–	2	2	2	0	–	–
3	Nagargali	2	–	2	2	2	0	–	–
4	Dandeli	2	2	2	2	2	2	1	1
5	Kulgi	1	2	2	2	2	2	2	2
6	Virnoli	2	2	2	2	2	2	1	1
7	Gund	1	2	0	2	2	2	1	1
8	Jagalbet	2	2	2	2	3	2	1	1
9	Sambrani	0	0	2	2	2	2	1	1
10	Supa	2	0	2	2	2	2	1	1
11	Kadra	1	2	0	2	2	0	0	0
12	Ankola	0	1	0	1	2	1	1	1
13	Karwar	1	0	0	2	2	0	0	0
14	Sirsi	0	0	0	0	2	0	0	0
15	Siddapur	2	0	0	0	2	0	0	0
16	Janmane	0	2	0	2	2	0	0	0
17	Hulekal	3	2	0	2	2	0	0	0
18	Yellapur	1	2	0	2	2	2	1	1
19	Manchikere	0	2	2	0	0	0	0	0
20	Mundgod	0	0	2	1	2	0	1	2
21	Kirwatti	0	–	–	–	–	–	1	1
22	Honnavar	2	–	–	2	2	–	–	–
23	Gerusoppa	3	2	1	2	2	–	–	–
24	Kumta	2	–	–	–	2	–	–	–
25	Bhatkal	0	2	–	–	2	0	–	–
26	Katur	0	1	2	2	2	0	1	1
Area No. 2—**Crestline**									
1	Byndoor	2	–	–	–	2	–	–	–
2	Sagar	1	2	2	2	2	0	1	1
3	Coondapur	1	1	0	1	2	1	0	1
4	Sankaranarayana	0	1	0	0	2	0	1	1
5	Hebri	0	1	0	0	1	1	0	0
6	Moodabidri	0	1	0	1	2	0	1	0
7	Karkala	0	1	0	1	2	0	1	1
8	Venur	0	1	0	1	2	0	1	1
9	Sringeri	0	2	0	1	2	0	0	0
10	Agumbe	0	1	0	1	2	1	0	1
11	Belthangadi	0	1	1	1	2	0	1	1
12	Mudigere	1	1	2	1	2	0	0	1
13	Manjarabad	2	1	0	1	2	1	1	1
14	Uppinangadi	2	1	0	1	2	–	–	–

Sl. No.	Name of range	Elephant	Gaur	Spotted deer	Sambar	Wild pig	Wild dog	Panther	Tiger
15	Puttur	0	0	0	0	2	0	0	0
16	Panja	1	0	0	1	2	0	0	0
17	Subramanya	2	1	1	1	2	2	2	0
18	Sulya	2	1	0	1	2	–	–	0
19	Sampaje	2	1	0	2	2	2	0	0
20	Bhagamandala	2	1	0	1	2	–	–	–
21	Makut	3	1	0	1	2	1	1	1
Area No. 3—**Malnad**									
1	Hosanagar	0	2	0	2	2	1	0	1
2	Kalasa	2	2	2	2	2	0	0	2
3	Balehonnur	3	2	2	2	2	1	1	1
4	Muthodi	3	3	3	3	3	2	2	2
5	Hebbe	3	3	3	3	3	2	2	2
6	Lakkavalli	2	2	2	2	2	2	0	2
7	Umblebyle	2	0	2	2	2	2	0	0
8	N.R. Pura	1	2	1	2	2	1	1	1
9	Chickagrahara	1	2	1	2	2	1	0	1
10	Anandapuram	1	0	2	2	2	0	1	1
11	Shankar	1	0	2	2	2	0	0	0
12	Sacrebyle	2	2	2	2	2	1	1	1
13	Ayanur	2	1	2	2	2	0	0	0
14	Rippenpet	2	2	2	2	2	0	1	1
Area No. 4—**Mysore Plateau**									
1	Bandipur	4	2	4	3	3	3	2	2
2	A.M. Gudi	4	2	3	3	3	3	2	2
3	H.D. Kote	3	2	2	2	3	2	2	2
4	Kakankote	4	2	3	2	3	2	2	2
5	Begur	4	2	3	2	3	2	2	2
6	Hediyal	3	2	3	3	3	3	2	2
7	Nagarhole	3	3	3	3	3	3	3	2
8	Titimati	3	2	2	2	2	2	2	2
9	Kalhalla	3	2	2	3	2	3	2	2
10	Sunkadakatte	3	2	2	3	2	2	2	2
11	Anthrasanthe	2	2	2	2	2	2	2	2
12	Gundlupet	3	2	2	2	2	2	2	2
13	Murkal	3	2	3	3	3	2	2	2
Area No. 5—**Kollegal hills**									
1	Anekal	1	0	1	1	0	0	0	0
2	Sathnur	2	0	1	2	2	0	0	0
3	Mahadeswaramalai	3	2	2	2	2	2	1	1
4	Ramapuram	2	0	2	2	2	0	0	0
5	Hanur	2	0	2	2	2	2	0	0
6	Kollegal	3	2	2	2	2	2	0	1

Sl. No.	Name of range	Elephant	Gaur	Spotted deer	Sambar	Wild Pig	Wild Dog	Panther	Tiger
7	Kanakapura	2	0	2	2	2	0	0	0
8	Chamarajnagar	2	2	2	2	2	2	2	2
9	B.R. Hills	2	2	2	2	2	2	1	1
10	Punjur	2	2	2	2	2	2	1	1
Area No. 6—**Maidan**									
1	Ranebennur	0	0	0	0 Blackbuck - 3	0	0	0	0
2	Raichur	0	0	0	0 Blackbuck — 1	0	0	0	0
	In addition 23 other ranges were screened.								

4 = very common, 3 = frequent, 2 = present, 1 = rare, 0 = absent, - = no information

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THE BIRDS OF GREAT AND CAR NICOBARS WITH SOME NOTES ON WILDLIFE CONSERVATION IN THE ISLANDS

HUMAYUN ABDULALI

(*With four plates*)

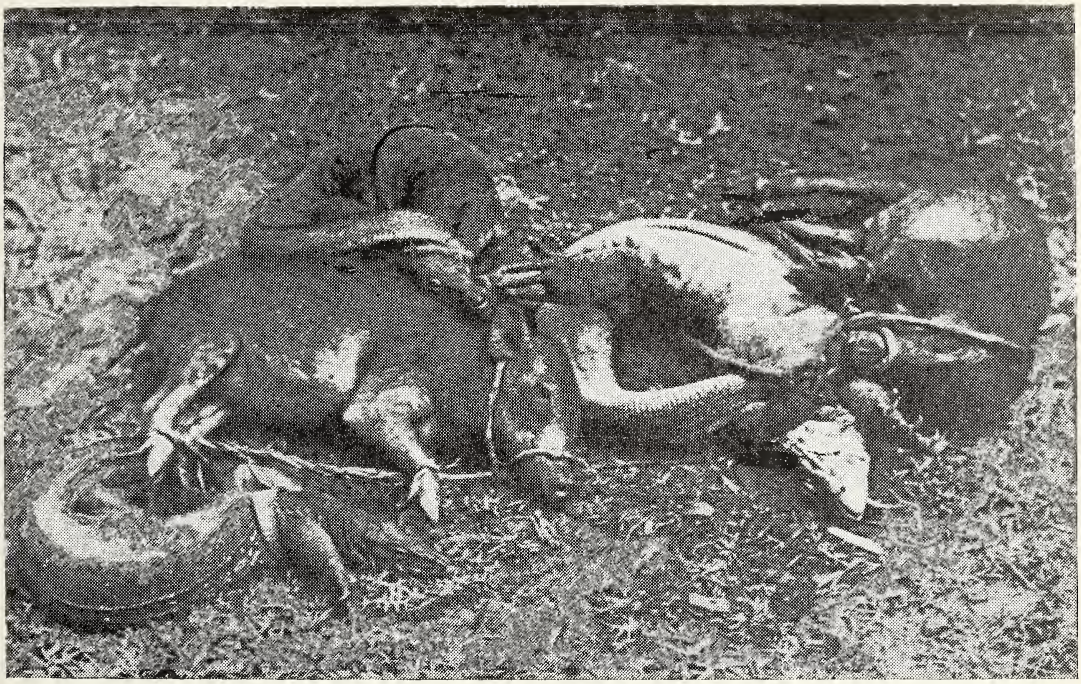
This is a report, mainly ornithological, of the writer's seventh and eighth trips to the Andaman and Nicobar Islands. Collections were made on Car and Great Nicobar and the specimens obtained permitted the addition of a new species of owl, *Otus magicus*? to the list of Indian birds, the description of new races of *Amaurornis phoenicurus* from Central Nicobars, and of *Macropygia rufipennis* and *Ninox affinis* from Great Nicobar. Attention has been drawn to the possibility of separating additional indigenous races of *Spilornis cheela*, another *Amaurornis phoenicurus* and *Zosterops palpebrosa* from Great Nicobar.

The Blacktailed Godwit (*Limosa lapponica*) and the Sanderling (*Calidris albus*) obtained at Car Nicobar are additions to the list of birds recorded from the Andaman and Nicobar Islands. 9 species are added to the list from Car Nicobar and 19 to Great Nicobar. Field and other notes are included.

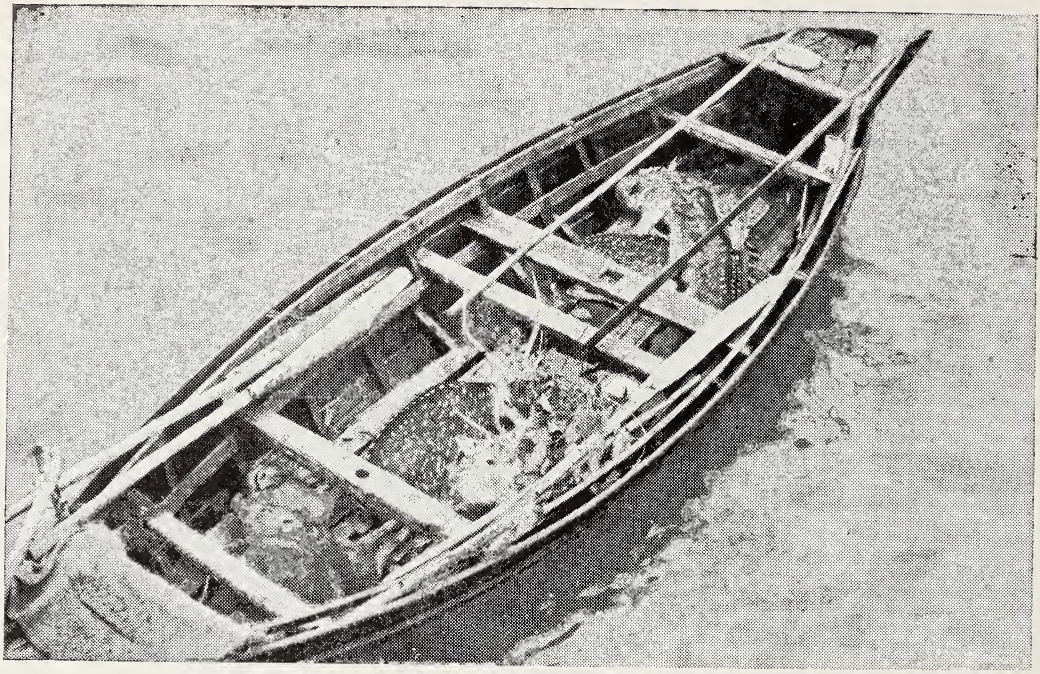
Every trip to the Andamans and Nicobars produces material which adds something to our knowledge of the birds and beasts of the area. Taxonomically, particularly regarding birds, the main reason is the fact that the first collections were made in the last century before the recognition of subspecies, and the type localities were just listed "Andamans" or "Nicobars", sometimes even "Andamans *and* Nicobars", ignoring the possibility of different forms having evolved in the 225 odd islands far from the mainland, and strung out over almost 500 miles. These islands form at least five separate archipelagos or biogeographical units. Due to greater attention given to collecting rather than to observation, little or nothing has been recorded regarding the field habits of the birds, and it will be quite some time before we have information equivalent to that pertaining to Indian species, which in itself is far behind that available for other parts of the world.

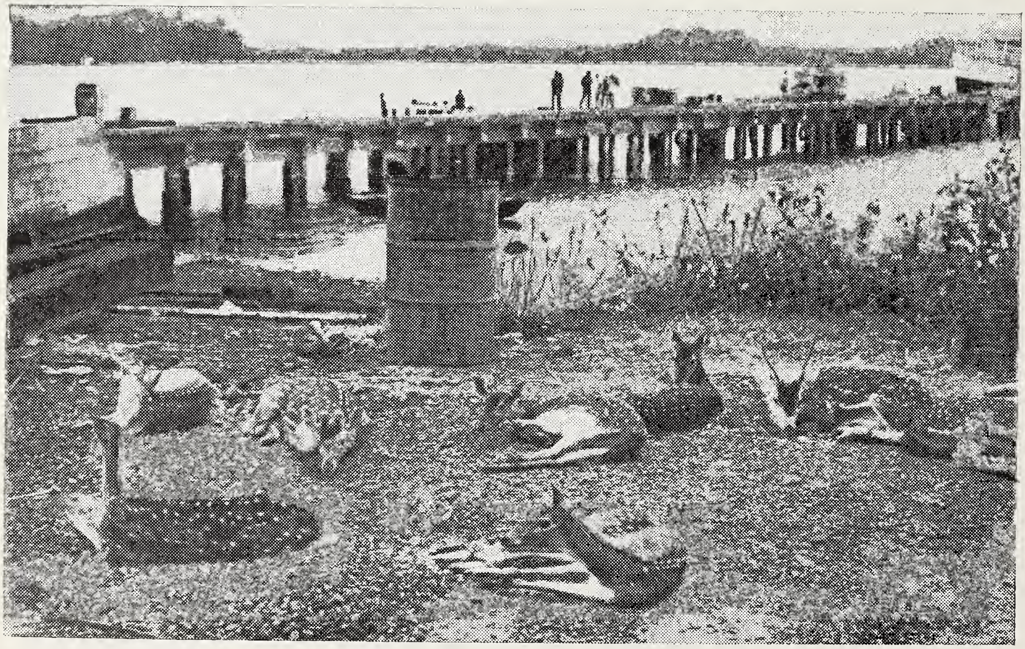
For these reasons I have been anxious to make representative collections in the different areas. Transport between the islands is difficult and irregular and trips aimed at one group have on more than one occasion found me in another. In 1966 I left with the hope of covering most of the Nicobars, but as mentioned in my earlier report (1967) I lost 10 days on a small clearing on the shore of Great Nicobar near Campbell Bay with the sea on one side and the impenetrable forest on the other. Movement was restricted to the beach when the tides permitted, and a few hundred yards inland.

I then obtained an owlet which I listed as *Otus scops nicobaricus* (Hume). This was referred to in a foot-note in INDIAN HANDBOOK (*3* p. 265) and Dr. J. Marshall (Auk, January 1972) when reviewing the book drew attention to the wing being too large for any scops owl. Further correspondence with him resulted in his visiting Bombay to examine the specimen, but he was unable to identify it. His inability to obtain permission to visit Great



The Andaman Pig and the Water Lizard (*V. salvator*) both in Schedule A of Wildlife (Protection) Act 1972 are trapped in North Andaman and in the absence of refrigeration taken alive to Port Blair, often with broken limbs and other injuries.
(Photo : *Romulus Whitaker*)





. . . And so to market.
(Photos: *Romulus Whitaker*)

Nicobar led to his suggesting that I apply to the Frank M. Chapman Memorial Fund administered by American Museum of Natural History, who readily helped.

In 1975 I corresponded with the Chief Commissioner and upon his assurance that all possible assistance would be available, arranged for Rex Pimento, Field Assistant, B.N.H.S. and Cyrus Toorkey, a Bombay undergraduate and a promising bird man to get to Port Blair by sea from Madras, where I was to fly in *via* Calcutta and Rangoon. The sailings between the islands were roughly fortnightly and when I got to Port Blair on 18th March 1976, I discovered that it would be possible for me to get to Car Nicobar by a light-house ship which was leaving on the 20th and touching several out-of-the-way islands *en route.* I therefore cabled the Deputy Commissioner to off-load Rex and Cyrus at Car Nicobar and let me meet them there on the 23rd. I was aware that a formal permit to collect birds would be necessary and saw the local Divisional Forest Officer who was also acting as Chief Wildlife Warden for the whole State. He asked for a list of the birds which I wished to collect and upon my attempting to explain that it was hardly possible to prepare such a list, for we hoped to find some which had never been obtained before, he drew attention to Section 12 of the Wild Animals (Protection) Act 1972 which says (a) that the licence requires the previous permission of the State Government, and (b) that it should also be restricted to hunting the animals specified therein. The Chief Commissioner was away in India, but the Chief Secretary appeared to agree that a licence as asked for by me could be issued, and I left my application assuming that the formalities would now be completed, and sailed by the light-ship *Sagardeep.* The first stop was off Neil and Sir Hugh Rose Is., the latter bearing an automatic light-house. I landed with the party entrusted with carrying the gas cylinders to the top. The tide was in and movement was restricted to half a mile of sandy beach on the western shore.

Common Sandpiper and Lesser Sand Plover rested in the shrubbery near the beach. I disturbed a pair of Great Stone Plover out of the same cover and as they trotted out, I sat on the sand to watch them. They moved about and squatted occasionally, but were all the time very curious to know what I was. The slightly smaller female (?) trotted up to within 15 yards, giving another example of the lack of fear in places where man does not exist, and how this has accelerated the destruction of many species, immediately upon his appearance.

After lunch we rowed round the island and saw a few Blacknaped Terns on a rocky pinnacle in the sea, a couple of dark Reef Egrets and a pair of Whitebellied Sea Eagles on a tree. The ship's butler said that these birds were tamed and kept as free-flying pets around his home town, Goa. A party of dolphin sported some 50 yards from shore, turning over and jumping clear out of the water, offering some excellent shots for the camera.

On the 21st we arrived at North Cinque Island, having earlier seen a Tropic Bird (*Phaethon* sp.) in the distance. A pair of Great Stone Plover, frequented the beach, and a few more birds were seen, including several Jungle Crows (one carrying a white pigeon (?) egg), a Brown Flycatcher (*Muscicapa latirostris*), and Bronze-winged Doves which appeared darker than around Bombay.

On the ground under the trees I picked up a 3-foot snake which showed the most startling array of greens and blues which I had ever seen, and which I felt sure was something new and yet unknown.* It lived with me till the end of the trip but I did not have the courage to try and bring it in by plane, and it was unfortunately lost in the alternative arrangements made.

We reached Little Andaman just after sunset and at least two species of bats were hawking round the lamp-post near the pier. The Forest Officer took me for a drive and we saw a grey civet cat/linsang with dark spots and a pale monocolorous cat, high on its legs. Both animals need identification. Fireflies in a conifer made it look like a huge X'mas tree.

The following morning I walked along the road which did not exist when I had stopped for a short time in February 1966. I saw some 25 different birds. This 400 square mile island, has not yet been touched by any naturalist and will certainly produce surprises.

The *Sagardeep* got to Car Nicobar late at night on the 22nd and I was up at daylight (5 a.m.) to get ashore but could not make a landing until almost 11. Once ashore however, matters moved more quickly, a jeep having been sent by the Dy. Commissioner, Mr. Sanat Kaul, I.A.S., I drove to the Rest House at the southern end of the island and then went to see Mr. Kaul who was looking at some work along the shore. While speaking to him, I noticed a large wader in the mud and glasses showed it to be a Blacktailed Godwit (*Limosa lapponica*). Nearby were a few Sandplovers and Sanderlings. The Godwit and Sanderling, specimens of both which were obtained, are additions to the avifauna of the Andaman and Nicobar Islands!

The sailing for Great Nicobar was not due till the end of the month and with the jeep at our disposal, we scoured fairly thoroughly the whole island which is relatively flat and open country.

House Sparrows (*Passer domesticus*), no doubt introduced, had built a large globular nest in a tree, quite unlike what one usually sees, but which has been noted, in India.

Our attention was drawn to a small underground cave with two entrances at opposite sides, flush with the ground. Entry was made in a crouching position into pitch darkness, perhaps 30 feet underground. Stalactites dripped from the roof and the first attempt towards the slimy bottom resulted in a slithering crash. The roof of the cave was about 20 feet high and torchlight revealed white nests of the Greyrumped Swiftlets (*Collocalia fuciphaga*) stuck in the small vertical crevices right from the top to as low as 8 feet from the bottom. Most of them contained eggs and fledglings. While groping in the darkness we met a pit viper (*Trimeresurus albolabris* Gray)!

On the 26th, we drove along the circular road right round the island. Several Whitebreasted Waterhens were seen on this and other trips, and the pure white heads, on the basis of which I have described *leucocephalus*, were prominent. The absence of the white head in one no doubt indicated a juvenile plumage. On one occasion, a gunshot started these birds calling.

At high tide, 14 whimbrel were seen perched on a tree about 100 yards from the shore, and other water-birds, e.g. the Golden Plover, were collected on the aerodrome. Five watercocks were also put up from the grass along the edges of the run-way, "beating" with the jeep. A dark middle-sized rail was put up in the same area but we failed to secure it and it remains unknown.

Some of the coconut palms in plantations held football-like protuberances 15 to 20 feet from the ground which appeared to be made by termites but some black ants collected in one nest containing eggs have been identified as *Dolichoderus bituberculatus* Mayr. In one place, the nests bore holes in the centre which, together with the proximity of the White-collared Kingfisher, suggested that they were being used as nests by these birds.

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* A colour photograph of *Ahaetulla cyanochloris* Wall exhibited by R. Whitaker in the course of a talk on Andaman Reptiles was almost certainly the same.

The domestic pig was very abundant and seen in villages, on the shore, and in the forests. They were medium-sized animals, black, brown and pied, the young also being of mixed colour with none striped. No wild pig is known on this island. We were told of a large tract of grassland near Kakana Village which I thought might possibly hold quail. Our guide however persisted that such a bird did not exist and the half-hearted beat after a long trudge failed to produce anything.

On the 29th, we again got the opportunity of stealing a two-day march on the ferry boat and took off for Nancowry by the *Safeena* belonging to the Nancowry Trading Co.

We were again among old friends, including members of the above-mentioned organization, Benjamin, who had helped me during the 1966 trip and Surgeon-Lieut. Maitra, a member of the Society, who had corresponded with me earlier and sent to Bombay a specimen of the Hawk Owl (*Ninox*). With their assistance, we arranged for a trip to Trinkut Island to look for the Bluebreasted Quail, of which no specimen existed in Indian collections and the only record was of the type obtained by Abbott & Kloss at the turn of the century. The habitat which I had worked before was a large area under 'elephant grass' [*Imperata*(?) sp.] which is used for thatching the domed huts in the Nicobars. The first bird put up was a watercock but with an organized effort it was not difficult to obtain 4 quail which were put up as single birds, pairs and one party of 5 or 6. They rise with a very slight whirr and are really much too small to afford any sport. Upon our return to Nancowry, we received a message from Shri Kaul relaying one from the Chief Conservator of Forests at Port Blair in which it was said that "no bird-shooting was allowed without permission." Mr. Kaul who had been acquainted with the earlier negotiations, added that he had cabled to the Chief Secretary and was awaiting a reply. Hoping that the Chief Commissioner was now back in Port Blair, I sent off a long wire to him but our work was at a standstill.

Having already been away from my business for over a fortnight, I decided to leave the boys at Campbell Bay for the ferry-boat's next trip and to get back to Port Blair to see what could be done. I was therefore at Campbell Bay only on the 2nd April getting there by the ferry *Yarewa,* and returning the same night. Short walks along the new North-South and East-West Roads revealed over 20 kinds of birds (we found 4 nests of the Racket-tailed Drongo) and stressed the necessity of working the area under the changed and changing conditions.

On the way back we landed at Katchal where 10,000 acres of forest had been cleared and planted with rubber which was now 8 years old and ready for tapping. Another area had been cleared and put under the Nigerian Red Oil Palm which was also bearing fruit, but in both instances, the absence of labour and other supplementary arrangements prevented the tapping of rubber and the collection of the nuts for oil. This is another example of the unfortunate manner in which natural resources are being literally murdered by schemes and programmes prepared by people who have no indication of how they are to be completed and/or finalized.

Immediately upon arrival at Port Blair on 5 April I saw the Chief Commissioner S. M. Krishnatry with whom I had corresponded earlier and understood that he knew nothing about my trip until he received my telegram from Nancowry, which he had passed on to the Chief Wildlife Warden who again repeated that the formalities had to be completed and finally accepted an application for 100 specimens, consisting of not more than 5 specimens of any one species of bird or mammal, only 2 megapodes and no sea-eagles. This was still subject to the Chief Commissioner's endorsement but he agreed to my advising the party at Campbell Bay to proceed with the collecting.

While waiting for my plane to Calcutta, I looked in at the Port Blair Zoo and saw examples of 2 species of Serpent Eagles (*Spilornis cheela davisoni* and *S. elgini*) whose identity has been disputed. There was no doubt regarding their separateness and I will refer to this in some detail later. The Zoo also contained a few megapodes which had been captured on Megapode Island off Great Nicobar.

From the Rest House, I saw a snipe drop into the grass on one side of the road. As I watched, the bird scuttled across the road into the grass on the other side—I must confess that I had never before seen a snipe (except perhaps a dead one!) on a macadamized road!

At Calcutta, I looked in at the Zoological Survey and explained to Dr. K. K. Tiwari, Joint Director, the difficulties regarding collecting permits. Dr. Tiwari agreed to make another trip with me the following year and after much negotiation, we arrived together at Port Blair on 17 March 1977, accompanied by two assistants of the Survey, Messrs S. S. Saha and B. Roy. The Chief Commissioner was again away from town but an application for a collecting permit was left with the Chief Wildlife Warden.

The journey to Campbell Bay was relatively uneventful. Not being in charge, I could now afford to sit and watch. At Little Andaman, the Divisional Forest Officer met us on the boat and drove us about a mile down the road, saying that he had instructions from Port Blair to meet the party of the Zoological Survey, but made it quite clear that he would not permit us to collect any birds. Four live Hill Mynas (*Gracula religiosa*) were brought on board in a cage and we saw scarlet minivets building a nest. During our short stops at Katchal and Camorta, a number of frogs, toads, lizards and snakes were obtained. While waiting for flying foxes (*Pteropus* sp.) on the edge of heavy forest at Camorta, I saw two young men walk past with a 22° rifle. They said they were looking for pigeons but had got nothing. A gun in the same place would have got half-a-dozen of the larger pigeons as they flew over in the evening, sometimes 3 or 4 together.

We finally got to Campbell Bay on the 25th and the party was divided into two, one at the Rest House and the other in the village further down.

We stayed here till 11th April and during this time made trips along the North-South and East-West roads. The former ended at the Galatea River and the latter at Copenheit on the west coast. On one trip southwards, we found the road almost blocked by the top half of a fig-covered tree, which had caught fire, presumably by lightning, and fallen across. It was being removed by blasting! On another we got to the river to find a small boat with one oar. The tide was coming in and it was quite impossible to move the boat in any desired direction. We shouted for the aboriginal Shompens who live on the other side, but there was no response. Two trips were made to the west coast by road, and details of one to "Hawabil" (*Collocalia* Swifts) Cave are given under the species. Chenappa Bay and Laxman Beach were within easy walking distance. A small island, about 200 yards off-shore in the Bay was reached through waist-deep water at low tide. Pied Pigeons were said to roost here in numbers, but we only saw a few during the daytime.

This paper is mainly concerned with birds and in addition to those obtained on the last two trips I have, for the sake of completeness, included such earlier records from Great and Car Nicobars as I have been able to find.

When reporting on the birds of Narcondam Island, I had referred to my party collecting some birds in the Andamans which had not yet been examined. The taxonomic and other field notes are therefore split into three parts, the first two dealing with the birds of Great and Car Nicobar and the third being a miscellany of notes from the Andamans which will be published later.

On the first trip a dugong skull was obtained on Great Nicobar; this presumably extends the recorded range of this animal. Crab-eating macaques (*Macaca irus*) were occasionally seen, some with ½ and ¾ grown young. The females showed a distinct toque on the forehead. I shot a few bats which along with a fair number of frogs, toads, lizards and snakes are being reported upon by members of the Zoological Survey.

I have referred to difficulties created regarding permission to collect specimens for scientific purposes and feel that some associated remarks are necessary. A note in this respect is appended at the end of this paper.

ACKNOWLEDGEMENTS

Before I proceed with the list, I have to place on record my indebtedness to the American Museum of Natural History, who contributed from the Frank M. Chapman Memorial Fund and to the Bombay Natural History Society for having made a grant from the Charles McCann Field Work Fund, to the cost of the first trip, the Zoological Survey of India and Dr. K. K. Tiwari in particular, for the collaboration which prompted the second effort, and to Mr. Sanat Kaul I.A.S., Deputy Commissioner at Car Nicobar whose sympathetic co-operation prevented the first trip from being a complete flop.

As in my earlier papers, the first number refers to that in Ripley's A SYNOPSIS OF THE BIRDS OF INDIA AND PAKISTAN (1961) and the 10 volumes of the HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN. The measurements, unless otherwise specified, are in millimetres, the wing being measured flat and the bill from the feathers of the forehead.

PART 1

GREAT NICOBAR

The area covered includes Little Nicobar and the several small islands in between and adjacent to them.

37* **Ardea purpurea manilensis** Meyen (Philippines) Purple Heron.

1 ♂ Great Nicobar 29 March 1977.

One was shot off a partly submerged log in a tidal stream along the North-South Road. In my earlier note [*JBNHS 64*(2) p. 150] I had referred to a female obtained at Trinkut, Central Nicobars, with little rufous or black on the underbelly and with slightly more rufous margins to the feathers of the upperparts. This is in similar plumage. Neither appears to be juvenile.

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* Birds not previously recorded from Great Nicobar are so marked.

		Wing	Bill	Tarsus	Mid toe & claw	Tail
Great Nicobar	♂	340*	121	110	125	104
Trinkut	♀	363	125	126	129	111

( ) **Ardea sumatrana sumatrana** Raffles (Sumatra) Dusky Grey Heron.

Abbott and Kloss (who also noted the Purple Heron) claimed to have seen them at Trinkut, Katchal and Great Nicobar. The species is omitted in INDIAN HANDBOOK.

39 **Butorides striatus** subsp. Little Green Bittern.

2: 1 ♂ 1♀ Car Nicobar.

The additional specimens confirm the increase in size from the Andamans southwards through Car, Central and Great Nicobar (*JBNHS 64* p. 151). Sharpe's *spodiogaster* which was said to have the underparts "darker sooty-slate colour, with a tinge of rusty on the abdomen, and with the ear-coverts of the same colour" appears to be found only in the Andaman Islands. They have very little white on the chin and throat and measure: wing 161, 164, 167; bill from feathers 55.5-57.7.

Those from Car Nicobar (4) are slightly larger (wing 170-176; bill 58.7-64.5), have grey underparts, the ear-coverts whitish, and the chin and throat largely white. In Central Nicobars, the size is barely larger (wing 167-179; bill 57.7-64.5) but the grey of the underparts and the throat is slightly darker, with the ear-coverts of the same colour. There is also a black streak down the throat. Though several were seen in Great Nicobar, and noted as larger than those seen further north, none were collected, and the only measurements available are the earlier ones from Little Nicobar (♀ wing 184) and Great Nicobar (♂ wing 185). The former was presumably the specimen referred to by Ripley (1944, *Bull. Mus. Comp. Zool.* p. 319) when he said that it agreed well with those from West Sumatran Islands and identified it as *actophilus* Oberholser, which Peters (1931, 1:104) had synonymised with *amurensis* Schrenck.

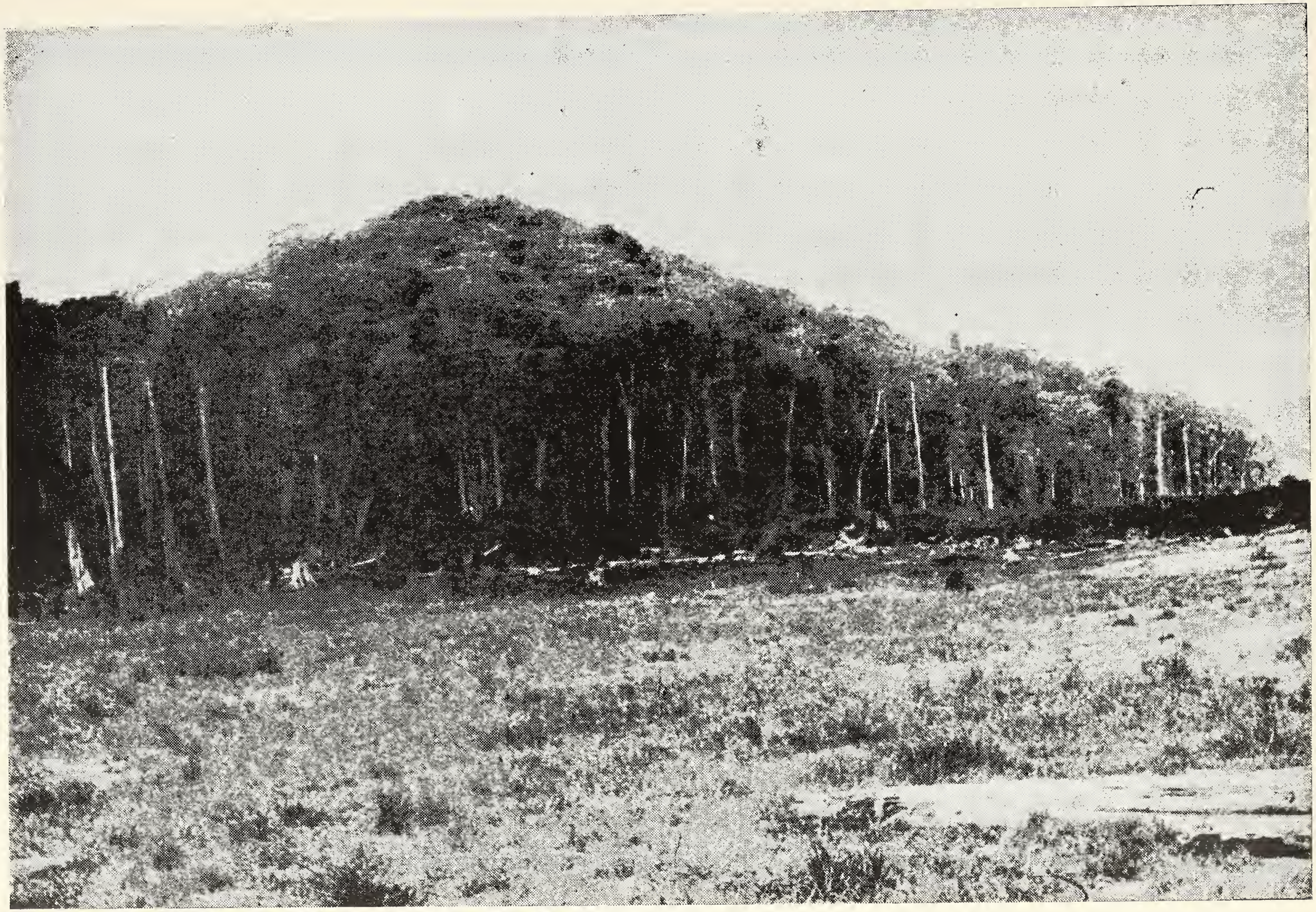
When listing the birds in the Bombay collection (1968, *JBNHS 65;* 192/3) I followed Ripley's SYNOPSIS and accepted Indian birds as *javanicus,* drawing attention to variations in colour and size. In the INDIAN HANDBOOK they are now said to be *chloriceps* (Bonaparte) (Type locality: Hitauri, Chisapani Garhi dis., Nepal), but four adults (1 ♂ 3 ♀♀) from Bombay and Ratnagiri on the western coast (wings 165-168) and a male from Ambala, Punjab (wing 173) have dark underparts (very different from the grey of *chloriceps*) and can only be separated from *spodiogaster* from the Andamans by their heavier bills. For the moment, I can do no more than restrict the type locality of *spodiogaster* to the Andaman Islands.

In 1976 I noted one on Car Nicobar with symmetrical white patches on both wings and another with white tips to both wings at Camorta. BNHS ♂ 22266 collected at Camorta on 25 March 1966 has the two outermost primaries on both sides pure white.

42* **Ardeola grayii** (Sykes) (Dukhun) Pond Heron or Paddybird.

1 ♀ Great Nicobar—March 1977.
Wing 198; bill 61; tarsus 56; tail 62

This was one of four seen flighting in the same direction over the East-West Road within 10 minutes about sunset. The species has not been recorded in Great Nicobar before.



The forests form close impenetrable stands which have to be cleared completely, for single trees can no more stand alone than can a single stem of grass.
(Photo: *S. S. Saha*)

Mechanical means of destruction have to be employed and much of the timber is removed by burning. (Photo : *S. S. Saha*)

51 **Egretta sacra** (Gmelin) (Tahiti) Reef Heron.

1 ♂ (grey) Great Nicobar 29.3.76; 2 ♀♀ (1 white, 1 grey) Car Nicobar 21.3.76

	Wing	Bill	Weight
♂	273	84	—
♀♀	288,276	81,81	395,400 gm

In the course of several trips to these islands, many dimorphic individuals of this species were seen, but there was nothing to suggest that the white and the dark forms hunt under different conditions—see *Ibis* (1971) *113*: 97-99; (1972) *114*: 552-555; (1973) *115*: 419-420.

The dark grey bill and bright yellow soles to greenish yellow legs and feet increase in flight the resemblance of the white form to *Egretta garzetta*.

54 **Gorsachius melanolophus minor** Hachisuka (Katchal I., Central Nicobars) Malay or Tiger Bittern.

I have some remarks on a single specimen obtained on Great Nicobar earlier by the Zoological Survey (*JBNHS* 64 p. 153).

57 **Ixobrychus sinensis** (Gmelin) (China) Yellow Bittern.

A ♂ and ♀ were collected on Great Nicobar (*JBNHS* 64: 143).

C. W. Benson, 1970, *Bull. B.O.C.* pp. 170-171 refers to material from the Andamans and Nicobars in London being relatively short-winged.

Of the four now available in Bombay, BNHS No. 22326 ♀ Bambooflats, Andaman has it 125 mm. while the three others are ♂ Andaman 134, 2 ♀♀ Central Nicobars 120, 129 (*Ind. Hand.* 1:87 *ex* Baker 129-136, one 143).

142* **Accipiter badius obsoletus** (Richmond) (Katchal Island, Central Nicobars) Nicobar Shikra.

In 1966, I had sent a ♂ specimen obtained at Camorta, Central Nicobars, to Dr. B. Biswas, who was in London, with a request that he try and determine its subspecific identity. In his reply he referred to a ♀ obtained by B. B. Osmaston on Great Nicobar on 21 April 1905, with which my specimen agreed and suggested that I should record it as *A.b. obsoletus* with reservation, as was done.

The B.M. specimen was marked *butleri*, presumably by Osmaston, who may not have had access to Richmond's description published in America only three years earlier, but the occurrence of the species in Great Nicobar has been so far overlooked. The subspecific identity requires further examination.

143 **Accipiter soloensis** (Horsfield) (Java) Horsfield's Goshawk.

Abbott and Kloss obtained 12 specimens on Central, Little and Great Nicobar and noted it as not uncommon, though a forest species and wary. There are no recent records.

173 **Haliaeetus leucogaster** (Gmelin) (Prince's I., Indonesia) Whitebellied Sea Eagle.

Occasionally seen along sea-shore. One adult with two young out of nest was seen at Laxman Beach. Two large stick nests in large trees within a couple of hundred yards of each other at Johnson's Bay could only have been of this species.

196a* **Spilornis cheela** subsp.? Serpent Eagle.

3: 1 ♂ (juv. largely white) 31 March 1977. 2 ♀♀ 1 (ZSI 33649 collected by P. K. Das) 22 April 1975, one, 2 April 1977.

Hume (1874, Stray Feathers 2:84) reported seeing a "Harrier Eagle undoubtedly *davisoni*" on Kondal Island between Little and Great Nicobar and Wimberley obtained a specimen there on 10 July 1876, which is now at the British Museum. Mr. Derek Goodwin while examining this (BM 1885.8.19.1605) for me discovered another 1885.8.19.1606 obtained by Davison on Montschal Island, just off Little Nicobar. Together with the specimen listed above, the 4 adults have wings 347-356 mm., which is smaller than *davisoni* and too large for *minimus*. In addition, all here are much paler than any of the others, particularly on the underparts, while Mr. Goodwin comparing those at the British Museum with 9 *minimus* available to him, says the same.

The two females mentioned above, both in heavily worn plumage, show traces of ocelli and barring on the breast and belly but the total effect is much paler than in other subspecies with marked breasts, e.g. *melanotus* and *davisoni* and, except for the smaller size, resembling some of the specimens of nominate *cheela* from Northern India.

Two specimens each of *S. c. bassus** (J. R. Forster, Sumatra) and *S. c. bido* (Horsfield, Java) (all with unmarked upper breasts) borrowed from Leiden, permit the following comparative measurements:

			Wing	Bill	Tarsus	Tail	Mid toe	+	Mid claw	Hind claw
Great Nicobar	♂	(juv.)	340	41	85	225	45	+	24	27.1
,, ,,	♀		360	40	82	226	45	+	24	27.7
,, ,,	♀		347	40	85	225	47	+	25	27.6
Kondal I.	?		353	—	—	—	—		—	—
Montschal I.	?		356	—	—	—	—		—	—
bassus Leiden No. 6	♂		360	37.5	89	225	46	+	22.3	24.4
bassus Leiden No. 16	♀		353	38	75	230	38	+	20	25.2
bido Leiden No. 26	♂		388	38	87.5	240	40	+	21.6	25.5
bido Leiden No. 17	♀		383	37.5	85	235	46	+	22.6	24.6
davisoni	♀	21900	393	42.5	87	250	48	+	22.5	26
	♀	21899	395	43	82	235	46	+	22	27.5
	♀	23106	391	41	89	243	52	+	21.2	27

In addition to the wing measurements, the Great Nicobar birds have the claws on the middle and hind toes larger than in the others. They also differ in having the thigh coverts finely barred, *contra* spotted in *bassus, bido* and *davisoni*.

Incidentally, contrary to the notes in Swann's Monograph (1945) the two specimens of *bido* have no white spots on their wing-coverts, where they are quite numerous in both *bassus* (*malayensis*).

My field notes from near Campbell Bay on 8 April, 1977, include the following:—

"Pale *Spilornis* with strongly barred tail".

"Pair of largish *Spilornis*, circling together on edge of, and over forest. Pale underparts completely spotted. A local farmer described an eagle which circled, whistled and took his chickens".

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* Stresemann (1959) has dealt with this name and recommended the dropping of *bassus* and replacement by *malayensis* Swann for Malayan and Sumatran birds.

The juvenile was shot seated in a tree with the crest puffed out and presenting a most remarkable appearance.

202 **Spilornis minimus klossi** Richmond (Pulo Kunyi, Great Nicobar I.). Small Serpent Eagle.

1 ♀ Campbell Bay, Great Nicobar. Wing 262, bill 32.7, tarsus 60, tail 175.

Peter's Checklist accepts *klossi* as a subspecies of *minimus*. We have no specimens of nominate *minimus* for comparison, but this arrangement, as in the case of *elgini*, simplifies the acceptance of this form from Great Nicobar alongside the larger form of *S. cheela* which has only recently been definitely recorded here.

( ) **Pandion haliaetus** subsp. Osprey

I saw one at Campbell Bay during my first visit in 1969.

( ) **Circus** sp.?

I got a glimpse of a slim-winged bird of prey over open fields which may have been some kind of harrier. *Circus pygarus*, Montague's Harrier has been recorded from the Andamans.

226 **Megapodius freycinet abbotti** Oberholser (Little Nicobar Island) Megapode.

H. P. Singh, the Range Forest Officer took us to see a megapode nest, some miles from camp. It was some 30 yards from the shore, about 5 ft high, roughly 44 paces in circumference and 14 paces over the top. It was composed entirely of sand with thin roots running through and indicating some permanence. Though two holes had been dug near the top, there was no trace of dead leaves or eggs or anything else to suggest a nest.

Another nest *c.* 24 km down the North-South Road was visited on 8th April. This was only 5 yards from the shore and generally similar to that described above. We were told that several hens had combined to build the nest whence 20/25 eggs had been taken last year, as also several birds. On the way back to the road we glimpsed a reddish chicken-like bird streaking through the undergrowth.

The R.F.O. had also visited Megapode I. to capture birds for the Port Blair Zoo. Six birds (2 ♂♂ and 4 ♀♀) were trapped on one of two nest mounds about 200 yards apart. One female attacked the ♂ which could be distinguished by an orange patch near the face. Both males died, and one snared female was devoured by a monitor lizard. The survivors were fed on boiled rice and crabs. In captivity, they drank fresh water though none was known to exist on Megapode I.

( ) **Amaurornis phoenicurus** subsp.

Sharpe (1894) described *insularis* from the Andaman and Nicobar Islands referring to 13 specimens, 9 from South Andaman and 4 from Camorta, Nancowry and Katchal in the Central Nicobars. No material from Car Nicobar (now separated as *leucocephalus*) was available to him, and when reporting on my first collection from the Nicobars (*JBNHS* 64: 159) I drew attention to birds from Central Nicobars again differing from those from Car Nicobar. It is necessary to restrict the type locality of *insularis* to the South Andamans.

A re-examination reveals that the birds along that line of islands can be divided into four groups:

345 ANDAMANS: *insularis* Sharpe (South Andamans).

Adults darker than Indian birds, with the white in front being restricted to a narrow stripe down the centre and bordered by black. The white on the forehead, 9-13 mm, is also more than in Indian birds, but less than in the next two forms southwards. The young bird has less white on the forehead and the dark underparts are grey rather than black.

345a CAR NICOBAR: *leucocephalus* Abdulali.

In addition to the all-white head, often including the nape, and the wider white stripe down the front, all five available have a varying extent of rufous on the edges of the rectrices, a character absent in others both from the Andamans and further south. In dry specimens the bill, legs and feet are bright yellow with the bill red at base. A single bird with a non-white head was seen on 26th March 1976 and the type specimen (BNHS 21547) which has a little black on the nape and whose underparts are greyer than in the others represent phases through which they presumably pass to adult plumage.

Ripley in RAILS OF THE WORLD (1977) has synonymised this with *insularis*, but I am not aware of his having had access to any specimens from Car Nicobar.

345b CENTRAL NICOBAR: 2 ♂♂ 2 ♀♀

As indicated before (*loc. cit.*) these birds differ from *leucocephalus* in the white of the head extending only halfway over the top of the head (about 15 mm), the more olive upper parts, their larger and heavier bills (from feathers ♂♂ 43-45 *contra* 42.5-43 in *insularis;* ♀♀ 36.5-39.5 *contra* 36-37.5), and the lack of rufous on the edges of the tail feathers. The measurements of the legs, feet and bill are similar to *leucocephalus* but the bills are heavier and bulkier than indicated by the length. They are quite different from those from Great Nicobar (*infra*).

On these differences, I name them:

Amaurornis phoenicurus midnicobaricus

Holotype: ♂ collected by Robert Grubh and P. B. Shekar at Nancowry, Central Nicobars, on 23 March 1966 and bearing BNHS Register No. 22444. Paratypes: 1 ♂ 1 ♀ Nos. 22572, 22445 *ex* Camorta and 1 ♀ 22571 Nancowry, Central Nicobars, all in March 1966. More material from U.S. National Museum was examined earlier.

345? GREAT NICOBAR: 3: 1 ♂ 2 ♀♀

The three new specimens are, according to the notes available, similar to the two from this area referred to earlier (*loc. cit.*) having smaller, greenish and less yellow bills, the white on the forehead only 8-12 mm. and olive-green legs and feet. Mr. Bond of U.S. National Museum tells me that the three specimens from Great Nicobar available to him have dark bills and narrow white frontal bands, being in these respects inseparable from their single specimen of *insularis* from the Andamans. The rufous on the underparts is also darker than in *midnicobaricus*. They are much larger than *javanicus* (wing ♂ ♀ 157-171 *contra* 148, 145) of which two specimens from E. Borneo and Lanuza, Surigao del Sur, in the Philippines were borrowed from the American Museum of Natural History. Except that their upperparts are greyer and do not have an olive tinge, the Great Nicobar birds are not separable from nominate *phoenicurus* and *chinensis* found in India, and may well be the same. Adult skins kept for some time acquire the olive tinge on the upperparts resembling that in juveniles. These descriptions are generally confirmed by the several single birds and pairs seen during the trip.

While the four subspecies occurring in the Andamans and Nicobars appear to be very distinct, single specimens from Narcondam Island (No. 23386 ♀ 30 April 1970), South Andaman (23387 ♂ 28 April 1970) and Nancowry (22571 ♀ 24 March 1966) with no rufous on the underbelly, very little white on the forehead, smaller bills and less brightly coloured legs and feet are probably first year or subadults of their respective resident races.

A pair was noted feeding in a dry nullah at dusk. One pecked on the ground, while the other picked seeds off standing grass. When alarmed they first opened and shut their wings and then ran.

371* **Pluvialis squatarola** (Linnaeus) (Sweden) Grey Plover.

Noted at Copenheit on west coast with other waders on 3 April 1977. I have also seen this bird at Car Nicobar and at Trinkut, Central Nicobars.

373 **Pluvialis dominica fulva** (Gmelin) (Tahiti) Golden Plover.

A single bird was noted on Great Nicobar on 1st April 1977. Flocks of 30/40 were seen on Car Nicobar on 23 March 1976 but included none in breeding plumage.

374* **Charadrius leschenaultii leschenaultii** Lesson (Pondicherry) Large Sand Plover.

Seen at Copenheit, Great Nicobar on 3 April 1977.

A specimen obtained on Car Nicobar had a 148 mm. wing.

384 **Charadrius mongolus atrifrons** Wagler (Bengal) Lesser Sand Plover.

2 ♀♀ Car Nicobar 23 March 1976; 1 ♀ Great Nicobar 5 April '77.

Wing 126-134; bill 18.5-20; tail 44, 50, 51; tarsus 30-31.

Birds seen in the Andamans and on Car Nicobar in March 1976 formed very compact flocks. Some had chestnut heads and one (1st April) a rufous patch on the breast.

385 **Numenius phaeopus phaeopus** (Linnaeus) (Sweden) Whimbrel.

386 **Numenius phaeopus variegatus** (Scopoli) (Luzon) Eastern Whimbrel.

Specimens were obtained on earlier visits. As discussed in the Narcondam paper (1974 *JBNHS 71* p. 497-8) the birds from this area appear closer to the eastern than the nominate form—or both races occur.

Whimbrel were seen at Copenheit, Great Nicobar, on 3rd April 1977 and at Laxman Beach on 13 April.

The bird was seen to plunge its bill into the sand right up to its forehead, but nothing was actually seen being pulled out. This species was often seen close to the Common Sandpiper.

394* **Tringa totanus** subsp. Redshank.

Seen at Copenheit, Great Nicobar 3 April 1977.

A ♂ obtained on Car Nicobar on 23 March 1976 has the wing 168 mm. and bill 50 mm., both larger than any others here including earlier specimens from Andamans (2) and Car Nicobar (1). The present specimen also has the breast more strongly marked than in any other, and attention may again be drawn to specimens from the Andamans in the British Museum, obtained in May, June, July and September.

396 **Tringa nebularia** (Gunnerus) (Norway) Greenshank.

Hume (1874, p. 299) had referred to a single male obtained by Von Pelzeln on Great Nicobar on 23 March. The bird is no doubt rare in this area, but there would appear to be no reason for my treating it as doubtful (1967, p. 161), having seen it myself on the Andamans and recently on Car Nicobar.

401 **Tringa hypoleucos hypoleucos** Linnaeus (Sweden) Common Sandpiper.

Occasional on shore. Often associated with whimbrel.

402* **Arenaria interpres interpres** (Linnaeus) (Sweden) Turnstone.

Noted at Copenheit on 3rd April, at Laxman Beach on 11 April and at Comorta on 12 April 1977.

406* **Capella stenura** (Bonaparte) (Sunda Islands) Pintail Snipe.

2: 1 ♂ 1 ♀. The fresh skins are appreciably darker on their upperparts than older ones which are rufous.

Common in short green grass land, bordered by *Cyperus javanicus,* once wet but now mostly dry; and within a few yards of dwellings and roads. A few were put up out of similar sedge under bananas, where domestic poultry were feeding.

434 **Dromas ardeola** Paykull (India) Crab Plover.

Abbott noted them on Katchal and Great Nicobar and Butler saw a flock of 60/70 on Car Nicobar. None have been reported afterwards.

443* **Glareola pratincola maldivarum** J. R. Forster (open sea in the latitude of Maldive Islands) Collared Pratincole.

A pair was seen on the beach at Galatea Bay, with sandplovers on 6th April 1977 and were markedly high on their legs.

468* **Sterna sumatrana sumatrana** Raffles (Sumatra) Blacknaped Tern.

6/8 on islet off Laxman Beach.

On 30 March 1976 at Nancowri small parties were noted settled on bouys and rocks. They fish in loose flocks, and occasionally dive vertically with a splash, though usually picking up their food off the surface.

478 **Sterna bergi** subsp. Large Crested Tern.

Seen at Palu Bhabi, Great Nicobar on 8 March 1966 (JBNHS 64 p. 163).

500 **Treron pompadora chloroptera** Blyth (Nicobars) Pompadour or Greyfronted Green Pigeon.

3: 2 ♂♂ 1 ♀

Common in twos and threes. On both trips several males and females were seen carrying nesting material usually to a tangle of climbers or into tufts of leaves, often a hundred feet or higher.

I got the impression that the single wing bar (*contra* two in *andamanica*) is very clearly visible in the live bird. The single female (28th March) marked breeding has a grey chin *contra* green in others from Central and Car Nicobar and the Andaman.

508 **Ducula aenea nicobarica** (Pelzeln) (Car Nicobar) Nicobar Green Imperial Pigeon.

1 ♂ 1 ♀ Campbell Bay.

A ♂ obtained on 28 March 1977 had enlarged testes. Another was seen visiting a fairly exposed sketchy crow-like nest 100 ft. or more up. ½ grown young out of nest and receiving food from adult seen on the same day. At Car Nicobar (1976) where it occurred in fairly open country, several different calls were traced to this species. When calling *ghoom* the throat swelled out. Is this a male call? The more frequent *kuk-kuk-coo* was accompanied by a jerking of the tail and sometimes a baying action. The calling no doubt attracts others. One ghooming was joined by another smaller (♂?) bird which settled next to it and uttered the same kind of call. After some time the larger bird moved along the branch and shoved him off.

Several got together on tall tree with bright red *jamun*-like fruit. Only the ripe red fruit was taken, and the birds had to walk along the branches and hop around to reach ripe fruit. A jump would sometimes take the bird further than needed. The longish beak was useful for plucking the fruit, assisted by contortionist movement, as in parakeets.

This species is believed to lay one egg, but a young bird was seen to be fed by another twice its size, and then hop on to a branch 5 ft. away, where it sat near another of its own size. No colour differences were visible between the adult and the young.

The southern birds from Central and Great Nicobar are slightly larger than the topotypes from Car Nicobar and show a slight tinge of green on the upperparts *contra* almost nil in the latter.

509 **Ducula bicolor** (Scopoli) (New Guinea) Pied Imperial Pigeon.

2: 1 ♂ 1 ♀ (77/9, 77/27) Campbell Bay.

None were seen on Car Nicobar but a caged bird was said to have been trapped a couple of months earlier. A male shot at Trinkut on 31 March 1976 had enlarged gonads, and a pair was seen on Camorta on 1 April 1976. On Great Nicobar they were occasionally seen, and also on a small island *c.* 150 yards off shore at Laxman Beach, where they were said to roost in numbers. A visit at dusk, however, showed no birds or signs of nesting. On another small off-shore island a bird appeared to be sitting on a nest in a climber. The calls include a "whoo-oom", slightly but distinctly longer than in *aenea*. The wings measured ♂ 240 and ♀ 233 mm.

525a **Columba palumboides nicobarica** Walden (Trinkut, Nicobars) Nicobar Wood Pigeon.

I had obtained a specimen at Great Nicobar on my earlier trip.

527b **Macropygia rufipennis** Cuckoo-Dove

In 1969 (*JBNHS 64*: 167) I drew attention to differences between birds from Great and Central Nicobars and later (1971, *loc. cit.* 68: 144) restricted the type locality to Central Nicobars. This was really a clarification of the earlier references to 'Southern' Nicobar in which the term southern is relative to Car Nicobar, where the species has not been recorded.

The additional material from Great Nicobar confirms that though there are no differences in size, the males differ from topotypical specimens in being:

1) darker, more blackish on the upperparts,
2) similarly, less rufous on the head,
3) more closely barred below and with less rufous on the underparts and around the 'face", and
4) with the outer web of the first four primaries showing a darker rufous and forming a less distinct patch of rufous in the closed wing (not *rufipennis*).

The single female appears more dusky and less rufous. On these differences I separate birds from Great Nicobar naming them after Dr. K. K. Tiwari, Joint Director, Zoological Survey of India, without whose assistance the last trip would not have been possible:

Macropygia rufipennis tiwarii subsp. nov.

Holotype: ♂ GNB 77/38 obtained at Campbell Bay, Great Nicobar on 8 April 1977.

Paratypes: 4 ♂ ♂ BNHS Col. No. 24210 collected on 8th April 1976; Z.S.I. Col. Nos. 33113 dated 2 April 1977, GNB 77/47 dated 7 April 1977, 33020 dated 4 March 1966 and 1 ♀ 33021 dated 4 March 1966, all obtained around Campbell Bay, Great Nicobar.

In both nominate *rufipennis* and *tiwarii* the bills are heavier and longer than in *andamanensis* from the Andamans.

Twelve specimens of the three subspecies have been examined and they include only two females.

A loud interrogative *who's-up who's-up, who-a-hoop*, and *kya-huwa, kya-huwa* almost certainly emanated from this bird. Following the first call, one was seen chasing another from branch to branch. 40 attempts were counted but no contact made. Twice when the ♂ (?) failed to follow up, the ♀ (?) returned to perch a few feet away and then sidled up towards to him, but flew away when approached. The chased bird appeared duskier and smaller.

Two of the males listed above had enlarged gonads.

544 **Chalcophaps indica maxima** Hartert* (Golapabung, S. Andamans) Emerald Dove.

In the field, both in the Andamans and the Nicobars, the birds were noted as darker and with a shorter tail than in those from India, (at least near Bombay), but these differences are not confirmed by the skins available. The only consistent difference is that the grey bands on the lower back are usually fainter or missing and this may account for the impressions mentioned above.

544a **Calaenas nicobarica** (Linnaeus) (Nicobars) Nicobar Pigeon.

1 ♂ Great Nicobar.

The Zoological Survey have a skin from Great Nicobar, but it was not seen on either of the last two trips. It is well known to the local shikaris as the large pigeon with a white tail, which feeds on the ground.

553 **Psittacula caniceps** (Blyth) (Nicobars) Blyth's Nicobar Parakeet.

1 ♂ 77/19, 1 ♀ 77/12. Upper bill red in ♂ and black in ♀.

♂ with heavy moult in wing on 30 March 1977.

Occasional. The loud *kraán kraán,* not unlike a crow's was often heard but the bird not easily seen, possibly because it called when seated in leafy trees. On 2 April 1976 a ♂ with a red bill was bobbing his head up and down before another. A pair with black chins sat in a high tree biting off and dropping bits of green leaves.

Though restricted to the Great and Little Nicobar Islands, the earlier specimens (doubtless captive birds), were from Penang and Wellesley Province in the Malay Peninsula and from Car Nicobar (Blyth J.A.S.B. 1863 p. 5 and 1875 p. 54). It is certainly a very popular cage bird in the surrounding areas.

556 **Psittacula longicauda nicobarica** (Gould) (Nicobar Islands) Redcheeked Parakeet.

77/3 ♀ Campbell Bay 26 March 1977. Iris white, partly yellowish. Gonads enlarged.

♂ with red of cheeks flowing into that of bill, flew up to a female and kept bowing and twisting, apparently trying to regurgitate. He fed her 21 times before she flew to a hole in a tree 20 ft away, clung at entrance and then flew away. In the bowing movements, the head is also turned in a circle.

Another was seen courting, moving his head down to his feet in a circular movement, going through a regurgitating (?) movement and then touching her bill.

580 **Cuculus saturatus saturatus** Blyth (Nepal) Himalayan Cuckoo.

3: 1 ♂ (wing 196) 2 ♀♀ (wing 179, 181) Campbell Bay.

The base of the bill and the inside of the mouth of the ♂ were orange-yellow. One ♀ shows a lot of rufous all over.

( )* **Surniculus lugubris** subsp. Drongo-Cuckoo.

In my earlier reports I had discredited the

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*Mukherjee and Dasgupta of the Zoological Survey of India (*Proc. Zool. Soc.* Calcutta, *28*: 133-135, published 25 June 1978) have referred to sexual dimorphism and agewise differences in the species and then revived Bonaparte's *augusta* (1850) from the Nicobars on the basis of 2 ♀♀ from Car Nicobar!

identity of a bird shot and lost by Kloss on Katchal Island. At Campbell Bay one was noted with some hesitation on 2 April 1976, but another undoubtedly identified on 7 April 1977. It was feeding on caterpillars off the branches of low open trees by roadside. The tail had a very short fork, the bill was long, thin and slightly decurved and there was a white streak on the back of its head.

592 **Eudynamis scolopacea dolosa** Ripley (Barren I., Andamans) Koel.

1 ♂ 77/36.

Wing 224; bill 34.2; tarsus 33; tail 223.

Together with another male (wing 226, bill 34.4, tarsus 32, tail 216) obtained on an earlier trip (BNHS 22654) the wings and tails are appreciably longer than of the others from Narcondam, Andamans and Central Nicobars.

Males were calling *ku-ooo* and *koo-uk* all day and night but the *kik-kik-kik* of the female was heard only once, and none seen on either trip.

The testes of the male collected on 2 April 1977 were enlarged but there is no evidence to show what species is parasitised here.

618b* **Otus magicus** (?) subsp.

1 ♀ 77/40.

In the introduction to this paper, I have mentioned how the 162 mm. wing of an owlet obtained in 1966 led to a useful grant from the Frank M. Chapman Memorial Fund for the first of these two trips.

The present specimen has an even larger (170 mm.) wing and Dr. Joe Marshall who has been studying this in detail is sure that it is an undescribed form but cannot decide of what species.

The stomach contained a mangled 4 inch gecko. Saha who collected the last specimen said the call was 'ooo-m'.

645* **Ninox scutulata obscura** Hume (Camorta, Nicobars) Brown Hawk-Owl.

The very distinct *coo-ook coo-ook* was heard near Campbell Bay at dusk on 4 April 1977. This species has not been recorded from Great Nicobar and the subspecies, at least, requires verification. Hume described *obscura* from a single bird obtained "near Camorta", Central Nicobars, and I have already drawn attention [*JBNHS 69*(1): 116] to subsequent specimens collected only from the Andamans which though currently accepted as *obscura,* do not agree with the original description in having their lores, forehead and throat as dark as the rest of the plumage and not yellowish/yellowish white as described.

647a **Niinox affinis** subsp. Brown Hawk-Owl.

7: 4 ♂♂ 3 ♀♀ Great Nicobar.

The 1976 trip obtained two specimens at Car Nicobar the type locality of *isolata* which together with two borrowed from Z.S.I. can be immediately separated from nominate *affinis* (Andamans) by their larger wings (♂ 205, 210, 211, ♀ 207 *contra* 3 ♀♀ 172, 177, 177), less heavily marked and whiter underparts.

The series from Great Nicobar can be distinguished from *isolata* by the characters given in table on p. 760.

The single specimen (♀ BNHS No. 24178 wing 208 mm) obtained by Dr. B. Maitra at Camorta on 16 October 1975 is not very well prepared and difficult to name.

Stuart Baker when describing *isolata,* from Car Nicobar (1927, *Bull. B.O.C. 47* p. 60) referred to eight specimens from "Nicobars, Trinkut, Camorta Island" and said that "though the (Central? Nicobar—H.A.) birds seem a little browner with less ashy tint on the head and back, the difference is slight and not of itself of subspecific value". There is no

Comparison between Brown Hawk-Owl from Great Nicobar and the race *Isolata*

<table>
<tr><th><i>Great Nicobar</i></th><th><i>isolata</i></th></tr>
<tr><td>1) Head dark and almost concolorous with back, which has no trace of rufous.</td><td>Grey on head forming distinct cap; back with rufous brown tinge.</td></tr>
<tr><td>2) Very distinct dark barring on upper surface of both webs of all primaries (except first).</td><td>Barring indistinct and barely visible.</td></tr>
<tr><td>3) Inner secondaries prominently barred yellowish white on inner webs.</td><td>Barring on only a few innermost feathers.</td></tr>
<tr><td>4) Smaller: Wing ♂ 194, 201, 202.
♀ 194, 197, 198.
Tail ♂ 115, 116, 121, 124
♀ 115, 116 (2).</td><td>Larger: Wing ♂ 210, 211.
♀ 205, o? 210
♂ 124, 130
♀ 122, 132</td></tr>
<tr><td>5) Rufous wash over white of underparts</td><td>More white visible</td></tr>
<tr><td colspan="2">6) Though the feathers on the forehead of all the specimens are ruffled to some extent, those from Great Nicobar appear to show a larger patch of white on the forehead.</td></tr>
<tr><td colspan="2">7) In series, the dark bars on the tail contrast more prominently against the rest of the background than in <i>isolata</i>.</td></tr>
</table>

evidence that he had access to any from Great Nicobar. The differences noted above appear to be sufficient to separate those from Great Nicobar from *isolata* and I name them:

Ninox affinis rexpimenti subsp. nov.

Type: Field No. GNB 77/452 ♂ collected by S. S. Saha at Magar Nulla, 8 km. from Campbell Bay, on East-West Road, on 5 April 1977. Testes enlarged.

Holotypes. ZSI 1 ♂ No. 33162 dated 31 March 1977, 2 ♀♀ 33165 and 33167 dated 31 March and 4 April 1977. BNHS 2 ♂♂ Nos. 24220/1 dated 7 April and 1 ♀ 24219 dated 6 April 1976.

The bird is named after Rex Pimento, Field Assistant, at the Bombay Natural History Society, who has twice accompanied me to the Andaman and Nicobar Islands and worked assiduously in the field.

Two males obtained on 31 March and 4 April had their testes, 4.5 × 2.2 and 9 × 4 mm.

At dusk (31st March) one flew out of forest on to the bare horizontal branch of a high dead tree and hawked 20-30 feet away. Another (3rd April) was shot off a tree hawking flying termites at dusk. This site was about a hundred yards away from the forest and the owl must have discovered it by seeing a Racket-tailed Drongo which was already operating. The owl was soon followed by bats.

As I have already indicated (*JBNHS 69* p. 117) I think it would be better to treat *N. affinis* (and its races) as subspecies of *N. scutulata*, and *obscura* as a separate species.

686* **Collocalia fuciphaga inexpectata** Hume (Andaman Islands) Greyrumped Swiftlet.

3: 1 ♂ 1 o? Great Nicobar; 1 ♀ Katchal.

The pale rump was noted at Katchal but not visible among a hundred birds circling overhead in good daylight, at Campbell Bay. In the hand and upon comparison with the material available in Bombay, the underparts appear browner than grey, the pale rump less distinct and the over-all effect blacker than in Andaman birds.

On 9 April we were taken in a *catamaran* rowed by three people to a "hawabil" (presumably adaption of "ababil"—Arabic for swift) cave about 10 km. north of Laxman

Beach and near Pigeon I. The trip took 3½ hours of hard rowing each way.

The cave is at sea-level in the face of a sandstone cliff, with the entrance roughly triangular, 15 ft high and 12 ft broad. The tide flowed right in and the waves breaking in through the entrance would not permit anybody to retain a footing. It was however viewed from a rock above high water-mark, almost on a level with the apex of the triangular entrance. Upon our approach, the first birds seen outside were a few White-bellied Swiftlets. A little later, greyrumped birds were also visible. One (wing 121 mm) was lying dead on the rocks outside, highly decomposed. From the rock outside one could see and photograph 6 nests of the latter, two with two eggs each and four with single eggs, on the wall at the entrance. These nests were largely white with the thicker basal portions reddish-orange. On the opposite wall were 2 complete nests (empty and old?) and another hanging in tatters which were reddish-orange all over and quite different from what I remembered of earlier nests at Chirria Tapoo etc. One *Khalasi*, who had collected nests here before, entered the cave from above avoiding the tide at the entrance. The cave extended at least a hundred feet inwards and sideways on both sides, forming a huge cavern of an unknown height. The disturbed birds flew out in hundreds through the narrow entrance, but it was not possible to catch them with a wet butterfly net. The *Khalasi* brought some nests, highly coloured and with only a fine strip of white at the upper edge. The reddish colour on the nests appeared to be a stain acquired by seepage from the rock.

The yellow nests on Katchal Island mentioned by Hume may have been similarly coloured.

Nests in the underground cave at Car Nicobar referred to in the introduction were pure white and on 25 March 1976 contained either two eggs or fledglings. The edges of an empty nest, presumably freshly built, were soft and jelly-like. Two young in a nest brought to camp, defecated outside the nest, squirting an inch away.

The floor of the cave was black with insect "packets" from the ends of which white grubs stuck out. Lord Medway, who has considerable experience of the habitats of these swiftlets, writes "... They were in all probability the larvae of case-making moths, genus *Tinea,* family Tineidae. The family includes the common clothes moths, and all members specialise in eating animal products of some sort. The guano-dwelling examples are common in caves in south and southeast Asia (in my experience). Their cases are made of fragments of insect exoskeleton, and they probably can breakdown chitin in their guts."

687 **Collocalia esculenta affinis** Beavan (Port Blair, South Andaman) White-bellied Swiftlet.

1 ♀

Occasionally seen.

723 **Alcedo atthis bengalensis** Gmelin (Bengal) Common Kingfisher.

Occasionally seen. Specimens obtained on earlier trips.

727* **Ceyx erithacus erithacus** (Linnaeus) (Benghala) Three-toed Kingfisher.

1 o? Campbell Bay, 27 February 1966.

728 **Ceyx erithacus macrocarus** Oberholser (Great Nicobar) Three-toed Kingfisher.

1 ♀ 6 April 1977 Campbell Bay.

The bird obtained in 1966 *supra* could not be distinguished from the nominate form. The present specimen which had enlarged ovaries and was probably breeding has a distinctly longer 39 mm. (cf. 31-34) bill and though slightly damaged the black spot on the forehead at the base of the bill is barely visible. The earlier bird does have a bill slightly heavier than *most* others from India, but the small black spot can be matched in a few Indian skins. More material is necessary to determine if both represent variations in *macrocarus* or if nominate *erithacus* also visits the islands, as I had suggested. I would again draw attention to the fact that while the nominate bird is accepted as a breeding migrant to the Andamans there are no records of the species from Car and Central Nicobars.

732 **Pelargopsis capensis intermedia** Hume (Galatea Bay, Great Nicobar) Storkbilled Kingfisher.

1 ♂ 1 April 1977 (77/29) with testes enlarged.

Not infrequent but elusive. One in forest cackled like a woodpecker and appeared interested (?) in hollow trees.

Specimen obtained on sea-shore.

739 **Halcyon pileata** (Boddaert) (China) Blackcapped Kingfisher.

In open valley on East-West Road with tiny stream running through it.

743 **Halcyon chloris occipitalis** (Blyth) (Nicobars) Whitecollared Kingfisher.

Hume saw them occasionally in Galatea Bay (S.F. 2 p. 75) and we saw it too.

870 **Pitta sordida abbotti** Richmond (Great Nicobar) Hooded, or Greenbreasted Pitta.

2 ♂♂ 8 and 9 April 1977. Wing 107, 110.

Compared to 3 (2♂♂ 1♀) obtained in early March 1966 the upperparts are dark, bordering on brown rather than green, as is also the case in earlier birds. None of them show the dark median line on the crown referred to in the original description.

One of the males had enlarged testes.

949* **Lanius cristatus cristatus** Linnaeus (Benghala) Brown Shrike.

There has been some difference of opinion regarding the occurrence of the nominate form in the Andaman and Nicobar Islands, but in the course of cataloguing the Bombay collection I finally identified a specimen from the Andamans as of this race. On 10 April 1977, two shrikes were seen near Campbell Bay, not far apart and the brown head and upperparts of one compared with the greyish white forehead in the other, prompts me to accept the first as of this race.

950* **Lanius cristatus lucionensis** Linnaeus (Luzon) Philippine Shrike.

Not common. Several birds glassed showed the greyish white forehead.

957 **Oriolus chinensis macrourus** Blyth (Central Group, Nicobar Islands) Blacknaped Oriole.

1 ♂ Campbell Bay. Bill 35 mm.

Common, Long-drawn *pi-hoo* early in the morning. Appears very large. Carrying food to nests on 27 and 31 March. Another pair visiting nest high up and carrying away droppings(?) on 31 March.

981 **Dicrurus paradiseus nicobariensis** (Baker) (Kondel, Nicobars) Great Racket-tailed Drongo.

On 2 April 1976 the birds were commonly seen and four nests were found along the road in the course of a short walk and another pair seen chasing a serpent eagle. Several nests with young and eggs were seen again in 1977. One settled in a tree with a large green grasshopper, pulled off the wings and feet and then flew to a nest to feed young still invisible under the rim.

The webs on the tail of one were constricted in the centre, not yet being free from the sheaths. The bird was twice seen on telephone wires in open country and also almost on the ground in grass-scrub land in the manner of the Common Drongo (*adsimilis*) in India. A party of 4 was hawking flying termites at dusk. The crest was quite distinct in all the birds glassed. One bird with crest and only one racket and some white on under tail-coverts, flew to bole of large tree, looked down carefully, then entered the hole, splashed in the water collected there, and then flew away 20 yards to then shuffle and preen itself.

Adult approached 2 young in nest with food thrice in 15 minutes (8.30 a.m.). Then the food was refused or not begged for, and the parent flew away and settled near another adult, which could be distinguished by its having only one racket in its tail, and who made no attempt to feed the young. The young at different times spread and flapped their wings.

Another pair of adults sat a few inches from each other and both quivered their wings, then flew to another tree and repeated the performance. This process was gone through thrice before they flew away in different directions.

986a **Aplonis panayensis albiris** Abdulali (Campbell Bay, Great Nicobar) White-eyed Glossy Stare.

White-eyed birds at Camorta and Great Nicobar. However, at Camorta on 11 April 1977 I saw a white-eyed adult feeding 2 streaked young which had brown eyes. Stomachs of specimens collected held figs but the persistant manner in which they probed into the circlets formed by epiphytes particularly on dead trees, left little doubt that they were looking for some other food.

Two females in immature plumage collected on Great Nicobar on 2nd April are marked as having enlarged ovaries.

At Car Nicobar (subsp. *tytleri*) some 200 birds were seen together on a large tree early on two successive mornings.

1018a **Gracula religiosa halibrecta** (Oberholser) (Little Nicobar) Hill Myna.

4: 2 ♂♂ 2 ♀♀

Quite frequently seen around Campbell Bay and pairs visiting holes in trees. A ♂ obtained on 26 March 1977 had its testes 10 × 5 mm. Birds at Camorta appeared smaller than at Great Nicobar.

1142 **Hypsipetes nicobariensis** Moore (Nicobars) Nicobar Bulbul.

In my earlier paper (JBNHS 64 p. 182) I had restricted this species to the Central Nicobars, but it may be worth noting that Hume (S.F. 2, p. 223) refers to Davison having seen this at Pilu Milu, which is very close to Little Nicobar.

These islands have not been worked again.

1402 **Rhinomyias brunneata nicobarica** Richmond (Great Nicobar) Olive Flycatcher.

This is restricted to Great Nicobar, but none were seen on the last two trips.

1464 **Tersiphone paradisi nicobarica** Oates (Great Nicobar*) Paradise Flycatcher.

None were obtained either on Car or Great Nicobar during our recent trips and there is nothing to add to my earlier notings (JBNHS 64 pp. 183/4). However, I omitted to record that both males collected at Trinkut and Camorta, in March 1966 were not only red, but also with enlarged testes. This supports the view that Oates's description of *nicobarica* which included white birds must refer to those from Great Nicobar and the type locality is hereby restricted thereto.* If it is established that the Central Nicobar population (from which a white bird has not yet been recorded) needs separation it will require another name.

1469 **Monarcha azurea nicobarica** (Bianchi) (Nancowry) Blacknaped Flycatcher.

Campbell Bay 2 April 1976 ♀ chivvying a Racket-tailed Drongo. On 3 April 1977 a ♂ and a ♀ were seen attending to two young out of nest, but yet begging.

1500a **Cisticola juncidis malaya** Lynes (Klang, Selangor, Malay States) Fantail Warbler.

Abbott and Kloss saw a *Cisticola* sp. at Great Nicobar and specimens obtained on Car and Central Nicobars were identified as of this race (*JBNHS 64*: 185). On a subsequent trip to Car Nicobar I saw them feeding in sparse grass, and jumping for insects. We did not see it on Great Nicobar.

1554* **Acrocephalus orientalis** (Temminck & Schlegel) (Japan) Eastern Reed Warbler.

1 Campbell Bay 7 April 1977. Wing 82 mm., bill 17, tarsus 27, tail 68.

The third and fourth primaries are almost equal and longer than the second; the notch on the inner web of the second is below the eighth primary. Several were seen in bushes in open grassland; the pale rump was prominent in flight and the pale eyebrow noticeable when glassed.

Warbler sp.

A largish warbler without eye-stripe and olive green upperparts was seen in grassland on 5 April.

1605a **Phylloscopus tenellipes** (Swinhoe) (Amoy) Palelegged Leaf Warbler.

The old record of one taken on a ship 10 m. east of Great Nicobar cannot be added to but several were obtained at Narcondam Island (*JBNHS* 71 p. 502).

1884* **Motacilla caspica caspica** (Gmelin) (Caspian Sea) Grey Wagtail.

Seen on both trips. Also on Car Nicobar and Camorta.

1914 **Nectarinia jugularis klossi** (Richmond) (Great Nicobar) Yellowbreasted, or Olivebacked, Sunbird.

8: 4 ♂♂ 3 ♀♀ 1 o?

These birds were quite common and two were obtained on both trips. The bills together with those of earlier specimen are larger than in Central Nicobar.

♂♂ (4) 20.5-21.9 *contra* (3) 18.4-19.6

♀♀ (2) 20.6-21.5 *contra* (3) 16.7-17.7 in 2

In addition, the 3 Central Nicobar females are a much brighter yellow below, and it is probable that a well-prepared series from both places would indicate separable populations.

Stuart Baker's *blanfordi* from Kondal between Great and Little Nicobar is generally accepted as synonymous with *klossi*. No specimens are available, but it is worth noting that Oberholser, when describing *proselia* from Car Nicobar first compared his type with *klossi* (which he said was from "the other Nicobar Islands") and then added: "It is, of course, readily distinguishable from *Cinnyris ornata blanfordi* (Baker) by its much smaller bill." Kondal is just off the northern end of Great Nicobar. On the next page he admitted restriction of *klossi* to Great Nicobar and it would appear from this that he accepted both *blanfordi* and *klossi*.

1929 **Aethopyga siparaja nicobarica** Hume (Kondal) Nicobar Yellowbacked Sunbird.

1♂ 1 o? East-West Road 77/7 and 77/8 on 27 March 1977.

The unsexed bird has a trace of a dark stripe down the front, as in the off-plumage of male *Nectarinia asiatica*. One seen on 2 April '76 with brown front and red throat.

On 26 March 1977 a ♀ was seen carrying building material to a *Nectarinia*-type of nest 10 ft up, suspended from a cane leaf overhanging a dry nulla in heavy cover about 30 yards from road. A ♂ was hanging around but not visiting the nest.

Another ♀ building against a roadside cutting had the nest with a long 'tail', very similar to the type seen near Bombay. A ♂ was seen at red inflorescence at base of cane-like plant (without spikes).

1936* **Zosterops palpebrosa** subsp. White-eye.

2: 1♂ 1♀ Laxman Beach, 26 March 1977.

Robert Grubh, Asst. Curator, B.H.N.S., had reported seeing white-eyes at Campbell Bay on the 1966 trip, but this was not mentioned (1967) and these are the first specimens obtained in the Great Nicobar group.

The subspecies *nicobarica* was described from "Nicobar Islands" which with the repeated statement that it did not occur on Great Nicobar, must refer to Car or Central Nicobar, and I am restricting the type locality to Nancowry in the latter. The present specimens are quite different from *nicobarica* from the Andamans, and Central Nicobars—olive on the upperparts with no trace of a yellowish wash, and with no yellow on the forehead. The underparts are greyish with signs of yellow in the middle, but the greenish-yellow (not yellow) patch on the chin is not connected therewith, being distinctly separated by a greyish breast. The tail feathers are almost black and lack the yellowish-green fringes visible in most. The general effect is that of Holdsworth's *Zosterops ceylonensis* from the hills of Sri Lanka, though smaller.

	Wing	Bill	Tail	Tail/ Wing Index
Great Nicobar ♂ ♀	51,50	11.2,11.5	33,32	64.3
ceylonensis 1♀, 1o?	58,57	12.3,13	36,39	65.2

The difference in the relative lengths of the 2nd (first developed) primary, one of the characters on which *ceylonensis* has been made a separate species, is not visible in any of the four specimens above.

The birds from Great Nicobar appear to be quite distinct, but several of the differing characters listed above are those of the single specimen on which Richmond named *ventralis* from Car Nicobar, where several *nicobarica* had also been obtained. This has been ignored by subsequent authors, and I can find no at tempt at explanation. More specimens from these islands and also of the surrounding races *auriventris, buxtoni, williamsoni,* etc. are needed to permit any decisions.

PART 2

CAR NICOBAR

39(?) **Butorides striatus** subsp. Little Green Bittern.

Common. Remarks under Great Nicobar.

44.* **Bubulcus ibis coromandus** (Boddaert) (Coromandel) Cattle Egret.

A pair was noted on the Car Nicobar aerodrome. I was told that it attended pig instead of cattle. Though common in the Andamans and having been obtained at Tillangchong, Central Nicobars, this is a new record from Car Nicobar.

49. **Egretta garzetta garzetta** (Linnaeus) (Orienti = Northeast Italy) Little Egret.

Noted.

51. **Egretta sacra** (Gmelin) (Tahiti) Reef Heron.

Occasional—remarks under Great Nicobar.

141. **Accipiter badius butleri** (Gurney) (Car Nicobar) Shikra.

On 29 March 1976, I got a glimpse of a

shikra which looked about the size of a myna. There are no records of the bird in recent years.

143. **Accipiter soloensis** (Horsfield) (Java) Horsfield's Goshawk.

Except for a single bird in a coconut grove in Car Nicobar on 15 March 1966, we failed to see this species.

173. **Haliaeetus leucogaster** (Gmelin) (Prince's Is., Indonesia) Whitebellied Sea Eagle.

Occasional. One seen carrying a garfish at Camorta.

254. **Coturnix chinensis trinkutensis** (Richmond) (Trinkut Is., Nicobar Group) Bluebreasted Quail.

4: 2 ♂ ♂ 2 ♀ ♀ Trinkut Is., 31 March 1976.

I found this bird on both the short trips to Trinkut, and though looked for, did not see it in much longer stays on Car Nicobar and Camorta. This may possibly have been due to our inability to get suitable areas properly beaten, for at Car Nicobar the local inhabitants denied knowledge of its existence and it was impossible to get them to beat the cover for any sustained period. Butler (*JBNHS* 12: 691) found it "Common on one or two small grassy plains on Car Nicobar" but stressed the fact that they were very hard to flush and he found the best way of shooting them was over a rope dragged by two boys. He also noted "Mul" as the local name for the bird.

At Trinkut they were beaten out of an extensive plain of 'elephant grass' [*Imperata*(*?*) sp.] similar to that used for thatching the domed huts of the neighbouring islands. In the course of a morning we put up 2 pairs, 2 single birds and one party of 5/6 birds. The specimens obtained all had undeveloped gonads. They rose with a very slight whirr and are certainly too small to permit any sport with a gun.

One crop was packed with tiny seeds, not of *Imperata*. On a sandy patch in sparse burnt and re-growing grass on the edge of standing grass, we picked up broken egg-shells, 25 mm x 19 mm, pale fawnish white with an olive wash and fine specklings. While they appeared to be rather large for this bird, the measurements are very close to the average for 100 eggs of the nominate form in Stuart Baker's *Fauna* (24.5 x 19 mm).

In the course of a routine examination of the species it is noticed that the single female from Supkhar, Balaghat, M.P., obtained 13 March 1959 (BNHS No. 20784) differs from 7 old skins from Assam and Burma, in having clearer colours above and below, with a broad yellowish brown stripe extending over the eyes on to the forehead not visible in the others and less marked on the underparts. No male from peninsular India is available, but a fresh well-prepared series from the two areas may confirm these differences.

330(?) **Rallus striatus** subsp. Bluebreasted Banded Rail.

Butler (l.c. p. 694) took a nest on Car Nicobar on 30 August. I got a glimpse of a dark rail which was probably this species.

345a. **Amaurornis phoenicurus leucocephalus** Abdulali (Car Nicobar) Whiteheaded Waterhen.

Notes in Great Nicobar section, *supra*.

346* **Gallicrex cinerea cinerea** (Gmelin) (China) Water Cock.

1 ♀ Car Nicobar.

5 more put up with a jeep driven through the grass on the sides of the runway at the Car Nicobar aerodrome. The single bird collected has a 201 mm. wing which is larger than accepted for females (172-184) and smal-

ler than for males (211-227). Compared to the material from India available in Bombay, the bill appears very short and thick.

371* **Pluvialis squatarola** (Linnaeus) (Sweden) Grey Plover.

Noted on Car Nicobar.

373. **Pluvialis dominica fulva** (Gmelin) (Tahiti) Golden Plover.

Also noted on Great Nicobar, *supra.*

374. **Charadrius leschenaulti leschenaulti** Lesson (Pondicherry) Large Sand Plover.

Occasional.

381. **Charadrius alexandrinus** subsp. Kentish Plover.

J. M. Dasgupta (*JBNHS* 73 p. 222) recorded a specimen obtained by Dr A. K. Mukherjee at Malaka, Car Nicobar on 19 February 1972, where it was seen in small numbers together with waders on the sea shore. The subspecies is not determined.

384. **Charadrius mongolus atrifrons** Wagler (Bengal) Lesser Sand Plover.

Also noted in Great Nicobar, *supra.*

385/6. **Numenius p. phaeopus/variegatus** Whimbrel.

As in Narcondam and other neighbouring islands, the birds occurring here are probably of both races, or an intermediate form.

388. **Numenius arquata orientalis** C. L. Brehm (East Indies) Eastern Curlew.

I had overlooked Butler's reference to a Car Nicobarese name *"Sakayok"* for this species and saw it myself on 24 March 1976.

391* **Limosa lapponica lapponica** (Linnaeus) (Lapland) Bartailed Godwit.

1 ♂ Car Nicobar, 23 March 1976. Wing 200 (IH. 202-216) very fat.

This species, not previously noticed in the Andaman and Nicobar Islands, was one of the first birds seen on this trip, in the mud on the sea-shore, together with Sanderlings (also previously unrecorded). The specimen was obtained from a party of three; several others, including one (?) in breeding plumage were seen.

The distributional map in BIRDS OF THE SOVIET UNION, *3:326,* shows the east coast of India within the range of *L. l. novaezelandae* Gray (= *baueri* Naumann) in which the rump and uppertail coverts are heavily barred. Compared with a single specimen of *baueri* from Japan, the present specimen, as also the others from India in the BNHS collection, all appear to be of the nominate race.

394(?) **Tringa totanus** subsp. Redshank.

1 ♂ Car Nicobar, 23 March 1976.

See notes under this species in Great Nicobar list, *supra.*

396.* **Tringa nebularia** (Gunnerus) (Norway) Greenshank.

Seen on Car Nicobar on 24 March 1976.

400. **Tringa terek** (Latham) Terek River (on Caspian Sea) Terek Sandpiper.

2 ♂ ♂ 1 ♀, Car Nicobar, 23 (2) and 27 March.

J. M. Dasgupta (*JBNHS 73,* p. *222*) noted some specimens obtained on Car Nicobar, where it would appear to be a regular visitor. It has been noted on Trinkut I., Central Nicobars.

401. **Tringa hypoleucos hypoleucos** Linnaeus (Sweden) Common Sandpiper.

Noted.

402. **Arenaria interpres interpres** (Linnaeus) (Sweden) Turnstone.

Common on Car Nicobar, and also noted at Camorta (13 April) and on Great Nicobar.

406. **Capella stenura** (Bonaparte) (Sunda Islands) Pintail Snipe.

Shot on Car Nicobar.

414.* **Calidris albus** (Pallas) (Coast of the North Sea) Sanderling.

As indicated under 391, several were noted in tidal mud with Bartailed Godwits almost immediately upon our arrival on 23 March 1976. This is a new record for the Andaman and Nicobar Islands, The two specimens obtained were badly damaged by a dog but the remnants are preserved.

422. **Calidris testaceus** (Pallas) (Holland) Curlew-Sandpiper.

Butler shot a party of six at Car Nicobar in September.

434. **Dromas ardeola** Paykull (India) Crab Plover.

Butler saw a flock of 60/70 on Car Nicobar, but there appear to be no recent records.

443. **Glareola pratincola maldivarum** J. R. Forster (Open sea in the latitude of Maldive Islands) Collared Pratincole.

The de Roepstorffe collection at Copenhagen contains a ♂ and a ♀ obtained at Camorta, Central Nicobars, on 25 December 1875. Both are in immature plumage with incomplete collars and small bills which suggest their having been hatched not far away.

I have already reported a single bird shot on the aerodrome at Car Nicobar, where on a later trip we saw at mid-day a pair soaring high in the air like birds of prey.

[481. **Anous stolidus pileatus** (Scopoli) (Philippines) Noddy Tern.

In Ripley's *Synopsis* (1961), this species was said to breed on small islets in the Nicobars, but this is now repeated with a query in *Indian Handbook* (3 p. 73)].

500. **Treron pompadora chloroptera** Blyth (Nicobars) Pompadour or Greyfronted Green Pigeon.

1 ♂ 1 ♀, 28 March 1976.

These were shot out of a party of 10-12 in one tree. Their bills were pale with a bluish tinge, darkish at base and white at tip.

508. **Ducula aenea nicobarica** (Pelzeln) (Car Nicobar) Nicobar Green Imperial Pigeon.

Not uncommon.

509. **Ducula bicolor** (Scopoli) (New Guinea) Pied Imperial Pigeon.

None were seen in the wild but a caged bird was said to have been captured about two months ago, indicating the possibility of seasonal movements between the islands. A few days later, we saw several at Camorta, Central Nicobars.

525a. **Columba palumboides nicobariensis** (Walden) (Nicobars) Wood Pigeon.

1 o? Car Nicobar, 25 April 1976.

Wing 251; tail 144; bill 25.

The five outermost primaries in one wing are in moult and about 150 mm. The other is fully grown and it is difficult to imagine its flying in this condition. The Car Nicobarese name means "water pigeon" for which I could not obtain an explanation.

544. **Chalcophaps indica maxima** Hartert (Golapabung, South Andamans) Emerald Dove.

Commonly seen feeding on roadside like *Streptopelia* sp. in India. See footnote to species on p. 758.

544a. **Calaenas nicobarica** (Linnaeus) (Nicobars) Nicobar Pigeon.

We failed to see this bird on the last few trips and it is apparent that the shelling of Battye Malwe, 19 miles south of Car Nicobar, where it used to breed in thousands has told on its numbers. It is hoped that the island will be made a National Park and an attempt made to study the ecology of these magnificent birds before it is too late.

Butler (1899) records that on Car Nicobar in August there was a large proportion of very young birds, with the head still covered with tiny quills.

556. **Psittacula longicauda nicobarica** (Gould) (Nicobar Islands) Redcheeked Parakeet.

Resident.

592. **Eudynamys scolopacea dolosa** Ripley (Barren I., Andamans) Koel.

A ♂ was seen on 28th March but none heard.

647. **Ninox affinis isolata** Baker (Car Nicobar) Nicobar Hawk-Owl.

3 : 2 ♀ ♀ 1 o?

Notes in part 1, *supra*.

686. **Collocalia fuciphaga inexpectata** (Hume) (Andaman Islands) Greyrumped Swiftlet.

Resident. See notes included in Great Nicobar, *supra*.

687. **Collocalia esculenta affinis** Beavan (Port Blair, South Andamans) Whitebellied Swiftlet.

Car Nicobar!

At Port Blair on 18 March 1976, we found four nests in an old Japanese gunpit with c/2, c/2, 2 hatchlings, and one young with a white belly.

723. **Alcedo atthis bengalensis** Gmelin (Bengal) Common Kingfisher.

One seen on 26 March 1976.

739. **Halcyon pileata** (Boddaert) (China) Blackcapped Kingfisher.

Car Nicobar in March 1976.

743a. **Halcyon chloris** subsp. Whitecollared Kingfisher.

I have already (JBNHS 68:405) drawn attention to the birds of Car Nicobar being distinct from *davisoni* and *occipitalis* (Blyth) and restricted the latter to Camorta, Central Nicobars. It may be mentioned that the key to subspecies in *Indian Handbook* (4:95) cannot be used for birds from the Andaman and Nicobar Islands, where all females have white underparts.

On Car Nicobar, several ant-nest* protuberances 15/50 ft up in coconut-palm plantations had holes in the centre which, together with the proximity of this bird, suggested their being used as nests. Davison has recorded their nesting in ants' nests in similar situation (quoted JBNHS 61: 544).

917. **Hirundo rustica gutturalis** Scopoli (Philippines) Swallow.

Birds were seen on earlier trips and specimens obtained in the Andamans and in Central Nicobars were identified as of this race.

926.* **Hirundo daurica** subsp. Striated or Redrumped Swallow.

Single birds were twice seen on Car Nicobar, but it is not possible to name the subspecies. It will be recalled that Vaurie (1959: 13) doubtfully named a specimen from Port Blair as *japonica* Temminck and Schlegel, but the species has not been recorded southwards.

950. **Lanius cristatus lucionensis** Linnaeus (Luzon) Philippine Brown Shrike.

The only specimen from Car Nicobar has been identified as of this race, but as in Great Nicobar (q.v.), I noted (23 March 1976) birds with no grey or white on the forehead, which were possibly of the nominate form.

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* One examined contained black ants identified as *Dolichoderus bituberculatus* Mayr.

957. **Oriolus chinensis macrourus** Blyth (Nicobar Is., Central group).

Common. On 23 March 1976 a bird was seen in a deep cup-shaped nest 15 ft. up. Oberholser's *eustictus* from Car Nicobar does not appear separable.

981. **Dicrurus paradiseus nicobariensis** (Stuart Baker) (Kondal, Nicobars) Racket-tailed Drongo.

Not common.

986. **Aplonis panayensis tytleri** (Hume) (Andamans) Glossy Tree Stare.

1 ♂

Some 200 birds were seen collected together on a large tree early on two successive mornings.

991. **Sturnus erythropygius erythropygius** (Blyth) (Car Nicobar) Whiteheaded Myna.

Common.

1122. **Pycnonotus jocosus whistleri** Deignan (Cinque I., south of South Andamans) Redwhiskered Bulbul.

Butler (1899) refers to Davison meeting it at Camorta and Car Nicobar where it had just been introduced, but said he had seen it in neither place. During my several visits it was quite common at Camorta and Trinkut, but not noticed at Car Nicobar.

1407. **Muscicapa latirostris** Raffles (Sumatra) Brown Flycatcher.

Specimens were obtained on an earlier trip.

1464. **Terpsiphone paradisi** subsp. Paradise Flycatcher.

I cannot trace any specific record of this species from Car Nicobar, and Butler's statement (1899: 401) that though he did not see any white birds, young birds were numerous does not make it clear that he saw them both on Car and Central Nicobars.

1468. **Monarcha azurea idiochroa** (Oberholser) (Car Nicobar) Blacknaped Flycatcher. 2 ♀ ♀ (1964).

1500a. **Cisticola juncidis malaya** Lynes (Klang, Selangor, Malay State) Fantail Warbler.

Specimens obtained on Car and Central Nicobars in 1964.

1592.* **Phylloscopus inornatus inornatus** (Blyth) (Darjeeling) Siberian Yellowbrowed Leaf Warbler.

One was glassed among trees on the shore while on a launch off-shore. Specimens were obtained at Narcondam (JBNHS 71, p. 502) on 26 and 31 March 1972, but this is an extension of its known distribution.

1726. **Monticola solitaria pandoo** (Sykes) (Ghauts, Dukhun) Blue Rock Thrush.

Von Pelzeln is reported to have obtained a young male at Car Nicobar on 24 February. There is no subsequent record.

1736. **Zoothera citrina albogularis** (Blyth) (Nicobars) Nicobar Ground Thrush.

A ♂, by plumage, obtained on Car Nicobar in 1966 does not quite agree with others from Central Nicobars. Additional specimens are needed to permit a decision.

1875. **Motacilla flava thunbergi** Billberg (Lapland) Greyheaded Yellow Wagtail.

Butler recorded it as a regular winter visitor and I had obtained a specimen at Camorta, further south.

1876. **Motacilla flava beema** (Sykes) (Dukhun) Blueheaded Yellow Wagtail.

Butler noted *M. flava* as extremely plentiful from October to late May and I have identified specimens from Camorta, as of this race (but see remarks *JBNHS* 64 pp. 186-187).

1884. **Motacilla caspica caspica** (Gmelin) (Caspian Sea) Grey Wagtail.

Its solitary habits do not make it conspicuous, but it has been noted by most observers and is no doubt a regular visitor.

1915. **Nectarinia jugularis proselia** (Oberholser) (Car Nicobar) Yellowbreasted Sunbird.

Common on coconut flowers and also in low shrubbery and grass, together with *Cisticola*. Osmaston took c/3 at Car Nicobar on 24 March. We saw a nest being built in a *Bombax* on 27 March 1976.

1936. **Zosterops palpebrosa nicobarica** Blyth (Nancowry, Central Nicobars) White-eye.

I have referred to Great Nicobar birds being different, but the few from the Andamans, Car and Central Nicobars, appear identical, Osmaston took a nest with 2 eggs on Car Nicobar on 18 March (Nid. 3, p. 193). See remarks under Great Nicobar.

***Passer domesticus** subsp.

On Car Nicobar, while driving through a village, I noticed a large globular nest in a tree and noted "Sparrows in mass nest in tree". Birds were undoubtedly seen but I did not re-examine it, and cannot recall the details of the evidence that prompted this note.

1970. **Lonchura striata semistriata** (Hume) (Nicobar Islands) Whitebacked Munia.

A large flock near the Car Nicobar aerodrome was glassed for some time and appeared to include individuals with black heads. However, none of the 17 birds that fell to a single round of dust shot showed this character. They differ from Andaman birds (*fumigata* Walden) in being slightly smaller, the bill is noticeably narrower, show pale edges to the dark feathers of the breast, and the pale centres of the feathers of the back show up as a fine streaking.

In four earlier specimens from Camorta, Central Nicobars, the streaking on the upperparts is perhaps slightly less prominent and which also indicate a slight diminution in size.

SOME GENERAL REMARKS ON CONSERVATION AND THE FUTURE OF THE ISLANDS

The Wildlife (Protection) Act 1972 as in other parts of India is administered by the Forest Department. During a week in Great Nicobar (1976) my party actually witnessed the capture and/or killing of 2 crocodiles, one Malayan python and one dugong, all of which are on the list of animals completely protected under the Act. The Forest officials in the Nicobars had no copy of the Act and they were quite ignorant of what was to be protected and what not. We understood that somebody had been held for collecting the edible nests of the swiftlets. A perusal of the Act reveals that this bird is not mentioned in any of the Schedules and neither the bird nor its nest can be protected under it. Having represented Bombay Natural History Society on the Indian Board for Wild Life for almost 20 years and being familiar with the working of this Board and also that of the Forest department, I am convinced that the only hope of saving wildlife in India is to take it out of the hands of the Forest Department and to hand it over to people who are genuinely interested in the subject and willing to devote their time, not only office hours, to this work.

The Islands have remained unmolested for many hundreds of years and the natural environment attained is highly specialised. In the forests, the trees grow to a height of 200 feet and more and the whole complex is so intricate that no single tree can, in all its magnitude, stand alone. As soon as any part of the forest is cut, the shoulder-to-shoulder support is lost and the individual tree liable to be blown down by the next gale. For this reason, areas which are cleared of forest have to be literally denuded, leaving completely bare areas for cultivation. The perfect crop has not yet been discovered and even though a family of refugees or retired servicemen may be able to farm a few acres, this will only be for a few years. At and near Port Blair, one can see the soil being washed into the sea and the denuded areas being turned into unproductive and really barren land. Robert Johannes (Reader's Digest, October 1978) has an interesting note on corals and their destruction due to silt and other causes. He refers to a study in Brazil which showed that whereas a hectare of tropical rain forest normally lost a kilo of soil per year to erosion, 13 *tons* were lost annually after deforestation. Various attempts have been made at cultivating imported cash crops but the overall effort is haphazard and unpromising. I have already referred to the rubber and palm oil efforts on Katchal Island.

On Camorta we saw hillsides which had been cleared of forest and were now under straggly growths of cashew nuts. This will require a considerable amount of labour and we do not know if it will be available.

A report on Land Utilization and associated problems in the Andaman and Nicobar Islands, by D. N. McVean, IUCN Consultant has been published in June 1976 by International Union for Conservation of Nature and Natural Resources, with the assistance of the Government of India. It refers to the damage which has been done in South Andamans and other places, consisting of "wasted forest resources, soil loss and reduced availability of surface water." It stresses the fact that the conversion of forest to plantations or crop or waste land leads to an immediate reduction in rain percolation, soon making the places uninhabitable.

They indicate that the yield is temporary and likely to die out in a few years making it necessary to encroach further upon the forest. The present allocations of land are on the basis of the average family, but what happens as it increases and there is a second generation? An earlier report (*c.* 1956) by D'Cruz & Lal of the Forest Department was more or less to the same effect. One wonders, how long such expert opinions will continue to be ignored.

Identical conditions apply to wildlife. The passing of pious resolutions on particular days of the year is not going to preserve our fauna. There must be more relevant knowledge to guide our action, and no serious attempts are made to study. Very recently, I learnt that Barren, Narcondam, North Reef and South Sentinel Islands had been declared sanctuaries. While this was indeed a laudable move, prompted no doubt by the recent studies of birds, crabs, snakes and other forms of natural history in the area, it was necessary that all the islands be separately examined by parties of experienced naturalists and ecologits. I wrote to the Chief Commissioner offering to get together a suitable team to undertake this work, but after several reminders, received a letter from the Chief Conservator of Forests, Andaman and Nicobar Islands, to the effect that the Administration had no programme to carry out ecological studies of the Wildlife Sanctuaries of the territory at present. Without this knowledge, we do not know what we are attempting to preserve and will not know when it is gone.

ECOLOGY OF THE BLACK-AND-ORANGE FLYCATCHER *MUSCICAPA NIGRORUFA* (JERDON) IN SOUTHERN INDIA[1]

Mohammad Ali Reza Khan[2]

(*With two plates and a text-figure*)

The paper deals with the distribution, status, habitat preference, food and feeding habits of the Black-and-Orange Flycatcher *Muscicapa nigrorufa* (Jerdon). The field work was conducted between September 1974 and September 1976 in the Western Ghats, specially in the Nilgiris (Tamil Nadu), of southern India. The entire distributional pattern and status of the species were determined in the Nilgiris and in other hills of the Western Ghats, starting from the Biligirirangans in southern Karnataka down to Kanyakumari in Tamil Nadu, including parts of Kerala falling within the Western Ghats. The species has been recorded for the first time from the Siruvani hills and the Nelliampathies of the Palghat district and Agastyarmalai of Kerala, and High Wavy Mountains of Tamil Nadu. The habitat requirements, food and feeding habits were observed and determined.

INTRODUCTION

The Black-and-Orange Flycatcher *Muscicapa nigrorufa* is a monotypic species and is endemic in the hills of the Western Ghats in southern India. Unlike other members of the genus *Muscicapa* (Muscicapinae: Muscicapidae, class Aves) it is little known and there exists very little information on its ecology. The literature on this flycatcher is meagre and deals with the taxonomy in great depth, and to some extent with its distribution, status and breeding (Jerdon 1862, Hume 1876, Bourdillon 1880, Davison 1883, Fairbank 1887, Ferguson 1898, Dewar 1904, Ferguson and Bourdillon 1904, Kinloch 1921, Baker 1924 and 1933, Baker and Inglis 1930, Whistler and Kinnear 1932, Ali 1935, 1942, 1949 and 1977, Nichols 1937, Primrose 1938, Koelz 1947, Ripley 1961, and Ali & Ripley 1972). However, the distributional range and status of the species still remained enigmatic. There existed several unsolved questions and unfounded statements in regard to the status and distribution of *M. nigrorufa.* Although some serious work has been done on the old world or muscicapine flycatchers (Muscicapidae) by Summers-Smith (1952), Campbell (1954-'55, 1959), Haartman (1956, 1967), Meidell (1961), Lack (1966) and many others in different parts of Europe; no such study on the flycatchers has been undertaken so far in this sub-continent. Therefore I undertook extensive field work to collect information on various aspects of the ecology and behaviour of the species. This paper deals with the ecological aspects including distribution and status of *M. nigrorufa*.

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[1] Part of Ph.D. dissertation, Ecological Problems Relating to Birds: Ecology and Behaviour of the Black-and-Orange Flycatcher *Muscicapa nigrorufa* (Jerdon); 1977, accepted by the University of Bombay.

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MATERIALS AND METHODS

Out of 23 months (September 1974 through September 1976) spent in the field about 11 months were devoted for the present purpose. There were altogether 27 pairs and a lone marked male *M. nigrorufa* which were closely watched for the study of ecology during this period.

A pair of Bausch & Lomb, 6 by 30, and another pair of Nautica 10 by 50, binoculars were used throughout the study. The following materials were used in the field: Altimeter, Rocar stop-watch graduated up to one fifth of a second, Pesola spring-balance graduated up to half a gram, Common precision balance, Steel measuring tape, fine-tipped divider, Fujica 35 mm camera with a 50 mm and a 85-205 mm zoom lenses and electronic flash; mist nets, numbered aluminium rings (size 'Z') of Bombay Natural History Society (hereafter BNHS) and coloured plastic rings. I also used a hand-made insect net, a killing jar with ether for soft-bodied animals and another with chloroform for vertebrates, and a plant press. Soft animals were preserved in alcohol whereas vertebrates in ten per cent formaline. Insects were sent to Tamil Nadu Agricultural University, Coimbatore; to B.N.H.S. and to Zoological Survey of India, Calcutta; and vertebrate specimens to B.N.H.S. for indentification. Most of the plant samples were identified in the field itself excepting a few which were sent to experts for identification.

As separate methods were followed for the study of distribution, status etc., these will be mentioned at relevant places.

STUDY AREA

The intensive field study was conducted in the Nilgiris of Tamil Nadu state, although a number of other hills lying between Mysore district of Karnataka state and Kanyakumari district of Tamil Nadu were also visited. The topography of the Nilgiris has been described in detail by Ranganathan (1938) and in the Working Plan of the Nilgiri Forest Division (1969). This district lies between 11°15′ to 11°45′ N. and 76°15′ to 76°E. at the junction of Tamil Nadu, Karnataka and Kerala where the Eastern Ghats meet the Western Ghats. It has an area of *c.* 2525 square kilometers and consists of a group of hills ranging in height between 900 and 2635 meters above mean sea level. The present study was undertaken mostly in the environs of three stations namely Coonoor (11°21′ N. 76°49′E) and Kotagiri (11°26′N. 76°53′E.) under Coonoor Taluk, and Ooty (11°24′N. 76°44′E.) under Ootacamund taluk of the Nilgiris. Coonoor is situated on the lower ridge of the main plateau of the Nilgiris at an average altitude of *c.* 1800 (1100-2000) m, whereas Kotagiri lies between 1700 and 2000 m above msl; Ooty-the popular name of Ootacamund—the district head quarters lies at an average altitude of *c.* 2200 (2000-2500) m, at the foot of the highest peak Dodabetta (2635 m)—the seecond highest peak south of the Himalayas.

Climate: The Nilgiris lie essentially in the tropical zone although they enjoy sub-tropical to temperate climate being conditioned by the mountain situation. The hills receive both the SW and NE monsoons, and the average annual rainfall for the district is 1226 mm, which usually does not go below 1000 mm in the interior of the plateau of above 4000 mm in the Upper Bhavani region (2200 m. msl). The average annual rainfall of Coonoor, Kotagiri and Ooty is 1500, 1600 and 1278 mm respectively. Although the annual rainfall is not very high, it is comparatively well distributed over the year.

The mean annual humidity of Coonoor is 68.66 per cent at 0830 hrs, and 78.33% at 0830 hrs in Ooty. According to Puri (1960) there is no moisture deficiency in any season during the year in some high peaks of the Nilgiris.

The mean annual temperature of Coonoor (1749 m) has been recorded as 17° centigrade and that of Ooty (2245 m) as 14.2°C by Champion and Seth (1968). The highest and lowest temperature records being 29.4°C and 2.2°C respectively for Coonoor, and 26.1°C and 1.7°C respectively, for Ooty.

Vegetation: A detailed description of the vegetation of the Nilgiris and other hills of the Western Ghats, south of Mysore is necessary to understand the distributional pattern and other aspects of the ecology of *nigrorufa*.

The natural vegetation of the Nilgiri Plateau consists of extensive grasslands covering rolling hills interspersed with numerous isolated compact, sharply defined small woodlands, termed 'sholas' meaning (Tamil) tropical rain forest (Plate I). Champion and Seth (1968) have classified these sholas as Southern Montane Wet Temperate Forest. The sholas occur in different parts of the Western Ghats usually above 1500 m msl, e.g. the Biligirirangans, Karnataka; the Nilgiris, the Anaimalais, the Palnis, High Wavy Mountains and Ashambu hills in Tamil Nadu; Siruvani hills, the Nelliampathies, High Range and the Agastyarmalai in Kerala. The composition of the sholas in different hill ranges may vary slightly.

The major plants of a typical shola are as follows: species of *Michelia, Gordonia, Meliosma, Elaeocarpus, Cinnamomum, Syzygium, Litsea, Neolitsea, Evodia, Ilex, Glochidion, Vaccinium, Ternstroemia* etc., form the top storey. Second storey, wherever present, is usually comprised of *Turpinia, Symplocos, Viburnum, Garcinia, Eurya, Vernonia, Euonymus, Memecylon, Hydnocarpus, Rhododendron, Hynea* etc. Shrubs include *Maesa, Lasianthus, Psychotria, Sarcococca, Polygala, Strobilanthes, Bambusa* and *Alsophila*. Lianas, scandent shrubs etc., include *Toddalia asiatica, Rosa, Mahonia, Rubus, Berberis, Caesalpinia, Smilax, Pentapanax, Jasminum, Elaeagnus, Ipomoea, Passiflora, Polygonum, Argyreia, Marsdenia, Piper* and *Gleichenia*. The ground cover is formed by *Oxalis, Erigeron, Hydrocotyle, Anotis, Laportea, Chlorophytum, Fragaria, Desmodium, Drosera*, and *Rannunculus*. The grasslands are mostly dominated by *Anaphalis, Helechrysum, Senecio, Conyza, Rubus, Osbeckia, Dipsacus, Viola* and *Poa*. Other plants around the sholas are *Rhodomyrtus, Dodonea, Hypericum, Lantana, Pilea, Eupatorium, Elatostemma, Girardinia, Ulex, Cytisus, Dentalion* etc. There is always an abundance of epiphytes like mossess, lichens, ferns and orchids.

The forest of the Ashambu hills, the foot hills of Agastyarmalai and the Chemmunimalai roughly fits to the Southern Hilltop Evergreen Forest type of Champion and Seth (1968) with *Hopea, Calophyllum, Dysoxylum, Artocarpus, Syzygium, Cinnamomum, Macaranga* etc., and a dense undergrowth of shrubs, reeds, cane and bamboo brakes. West Coast Evergreen Forest type includes the Brahamagiris, part of the Nilgiri-Wynaad, the Malabar-Wynaad, Top-Slip, Parambikulam in the Anaimalais where the dominant vegetation is *Hopea, Mesua, Vitex, Diospyros, Cyclostemon, Cullenia, Poeciloneuron* and *Syzygium*, and an undergrowth of *Ochlandra* and *Calamus*. The slopes of the Nilgiris and the Palnis are characterised by the Southern Subtropical Hill Forest consisting of *Calophyllum, Syzygium, Turpinia, Litsea* etc., and an undergrowth of *Strobilanthes, Ochlandra, Calamus* and *Acacia*.

Distribution and Status

To determine the overall distributional pattern of *M. nigrorufa* in the Western Ghats, I visited, at least twice (once in the breeding and again in the non-breeding season), the Biligirirangans and the Brahmagiris in Karnataka, the Nilgiris, Top-Slip (Anaimalais), Valparai (Grass Hills), the Palnis, High Wavy Mountains and Ashambu hills in Tamil Nadu. Parambikulam, Sholaiyar (Anaimalais), High Range, Cardamom hills, the Chemmunimalai, the Agastyarmalai and the Nelliampathy hills in Kerala. Additional information regarding Siruvani hills and High Range in Kerala were received from Mr. E. R. C. Davidar and Mr. R. Sugathan respectively. The Nilgiri-Wynaad and the High Wavy Mountains were revisited in March and September to November 1977.

In my survey trek I usually followed main roads, foot and bridle paths, all cutting across or skirting the sholas and other types of forests. Where there was no definite path I walked through or along the edges of sholas and evergreen forests, and along the game trails. In a day's walk I used to cover an average distance of *c.* 15 km. Considerable attention was paid to forest cover between 700 and 2500 meters above msl. The flycatcher's presence in a particular spot was usually detected from its characteristic call-notes (*chee-ri-rirr* or *chi-ree-rirr* etc.) or a whistling song (*whee-chee-ree-rirr* or *chee-ri-rirr* etc.). In the non-breeding season the presence of a pair was determined usually by the sightings of both the male and the female at close quarters. During the breeding season the presence of a pair was established either from the singing male and his accompanying mate or from an actual nest and its contents, or from parents who were found attending the fledglings. My experience shows that if a statement is made that the flycatcher is common in the Nilgiris it does not really mean in which particular vegetation or locality it is common. Therefore, I have specified the places and localities, or exact spots, in the different hills where the flycatcher was sighted.

The distributional range and status of *M. nigrorufa* are shown in Fig. 1 and Table 1. I found this flycatcher in the Biligirirangans, the Nilgiris, the Nilgiri-Wynaad, (Siruvani hills), the Nelliampathies, the Anaimalais, High Range, the Palnis, High Wavy Mountains, the Chemmunimalai, the Agastyarmalai and Ashambu hills (locations in the table). The lowest elevation at which I saw this species is *c.* 900 m at Aduramalai Tea Estate (abandoned), at the foot of the Agastyarmalai in Kerala, my highest record being *c.* 2625 m on Dodabetta in the Nilgiris (Tamil Nadu). I did not see the bird in the Brahmagiris, Kerala-Wynaad, Top-Slip, Parambikulam and Sholaiyar section of the Anaiamalis, Santhanpara, Peermade and Kumili in the Cardamom Hills. Neither did Dr. V. S. Vijayan see this bird in Top-Slip, Parambikulam and Sholaiyar section of the Anaimalais during his survey of these hills in early 1976.

My observations show that the Black-and-Orange Flycatcher has disappeared from places like Wynaad (*cf.* Davison 1883), Munnar township in the High Range (*cf.* Ali 1935 & Primrose 1938), Peermade and Santhanpara (*cf.* Ali, loc. cit.). The probable cause of this absence may be that the vegetation of these localities has altered appreciably after those authors visited these areas. The undergrowth of most sholas has been removed for raising Cardamom plantation. During my visits in January and June to those places I found that the banks of the streams flowing through them were virtually devoid of the one-time luxuriant undergrowth of *Ochlandra, Calamus, Pandanus* etc., which seem essential for the habitat of *nigrorufa* in these hills.

There appears no previous record of the occurrence of *nigrorufa* on the Siruvani hills, the Nelliampathies, the Chemmunimalai and the Agastyarmalai of Kerala and the High

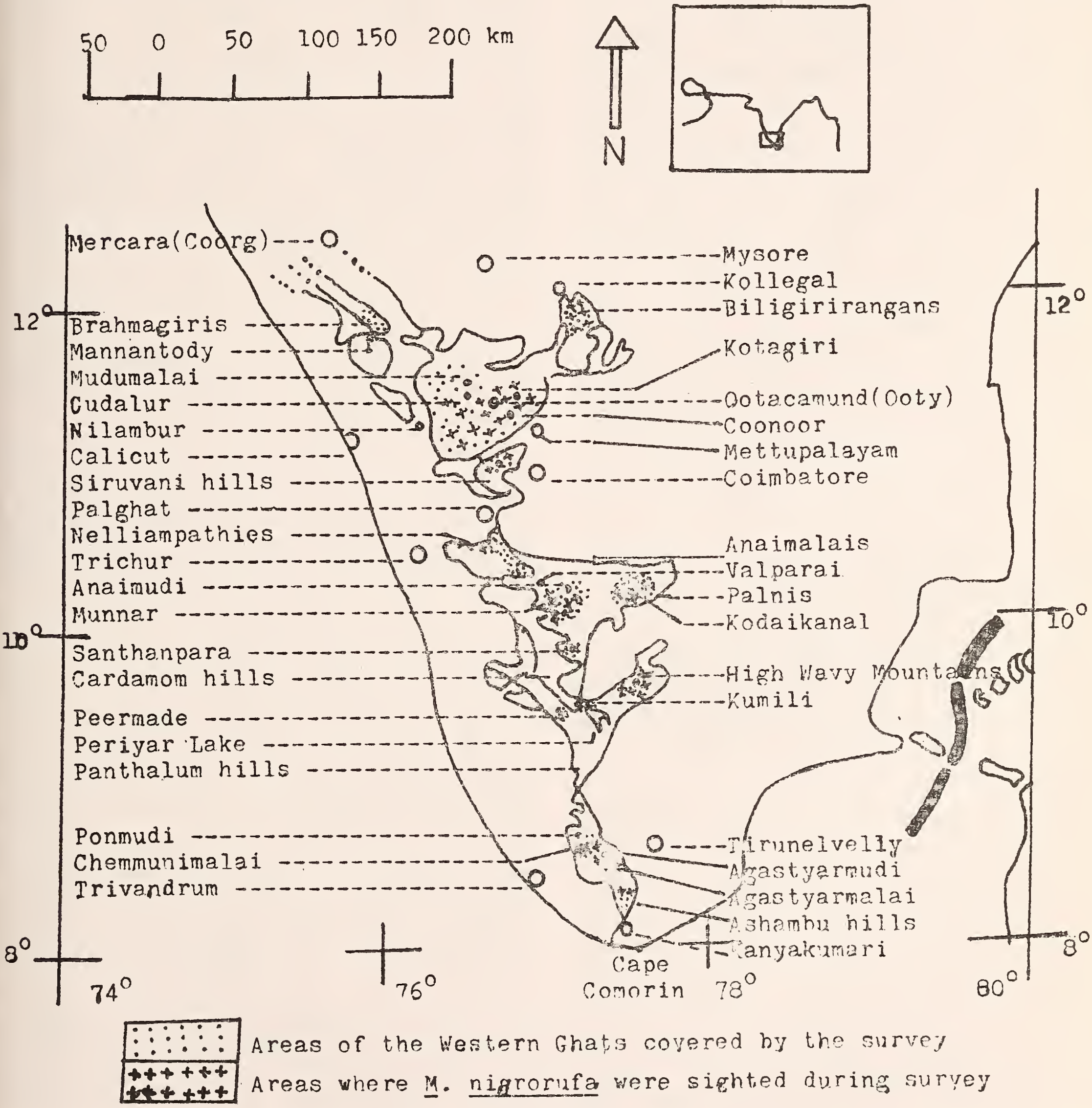
50 0 50 100 150 200 km
N
Mercara(Coorg)
Brahmagiris
Mannantody
Mudumalai
Gudalur
Nilambur
Calicut
Siruvani hills
Palghat
Nelliampathies
Trichur
Anaimudi
Munnar
Santhanpara
Cardamom hills
Peermade
Periyar Lake
Panthalum hills
Ponmudi
Chemmunimalai
Trivandrum
Mysore
Kollegal
Biligirirangans
Kotagiri
Ootacamund(Ooty)
Coonoor
Mettupalayam
Coimbatore
Anaimalais
Valparai
Palnis
Kodaikanal
High Wavy Mountains
Kumili
Tirunelvelly
Agastyarmudi
Agastyarmalai
Ashambu hills
Kanyakumari
Cape Comorin
12°
10°
8°
74°
76°
78°
80°
Areas of the Western Ghats covered by the survey
Areas where M. nigrorufa were sighted during survey

Fig. 1. Showing distribution of *Muscicapa nigrofufa* (Jerdon) in the Western Ghats, southern India. (Semi-diagrammatic)

Wavy Mountains (Madura district in Tamil Nadu). No ornithologists seem to have visited these hills except the Nelliampathies, which were surveyed by Kinloch (1921-1923) and Ali (1935) but without success. My records from the Siruvani hills and the Nelliampathies seem to be significant since these two ranges are situated on the northern and southern edges of the Palghat Gap respectively. Neither the BNHS's ornithological survey of the Eastern Ghats nor their bird banding camp came across *nigrorufa* in that area. Mitford's report of the occurrence of the species in the highest mountains of Sri Lanka, first doubted by Oates (1890), was subsequently rejected by Baker (1924) and others as unconfirmed. McMaster (1871) thought he saw *Ochromela* (*Muscicapa*) *nigrorufa* "among cliffs a few miles off Chikalda", in Maharashtra, but his report has never been confirmed. There is another statement in the Maharashtra Gazetteer (1968) presumably based on the above dubious record, that "In Melghat many more birds like the black-and-orange flycatcher (*Ochromela nigrorufa*), otherwise found in the Nilgiris and Ceylon (!) are seen". Neither Dr. Salim Ali nor others who have worked the Melghat area had ever came across the bird. The biotope here is altogether different from the Nilgiris; appropriate habitats are totally lacking, and this statement is palpably erroneous.

The climate, vegetation and the topographical features seemed to have affected the distributional pattern of *nigrorufa* in the Western Ghats. Mani (1968) emphasized these factors as affecting the distribution of high altitude insects. At present the bird is widespread in areas of medium rainfall, that is, an average annual precipitation of 1500 mm, as in the Biligirirangans, the Nilgiris, Siruvani hills, the Palnis, High Range and High Wavy Mountains. In these hills the temperature is considered to be optimum for montane vegetation as emphasized by Champion and Seth (1968). The vegetation here is dominated by the Shola type with patches of evergreen scrubs and plentiful undergrowth providing a perfect biotope for the flycatcher. The country is hilly and the upper plateaux are always above 1500 m msl. The flycatcher is either absent, rare or not common in the heavy rainfall zones where annual precipitation exceeds 2000 mm. Such areas include the Brahmagiris, the Nelliampathies, Top-Slip, Parambikulam and Sholaiyar of the Anaimalais, Santhanpara, Peermade, Chemmunimalai and the major portion of the Ashambu hills. These are all slightly undulating hills of medium elevation, usually below 1500 m msl. and the terrain is less rugged than the others mentioned above. The forests in these low hills are of the evergreen type dominated by tall trees.

I did not find *nigrorufa* in any part of the moist-deciduous forests like those in Masinagudi and Mudumalai in the Nilgiris, Bandipur in Karnataka, and Top-Slip in the Anaimalais, nor has it ever been reported from such forest in the Eastern or Western ghats.

Contrary to its description by earlier authors as 'patchy', I found the distribution of *nigrorufa* to be rather uniform in the upper plateaux of almost all hills situated between the southern part of Mysore in Karanataka and the northern portion of the Kanyakumari district of Tamil Nadu, usually above 1500 m msl. The range is restricted to areas lying between the Biligirirangans in the north and the Ashambu hills in the south, that is between c. 8°40′ to 12°N. and 76°60′ to 77°80′ E. The maximum width of the range does not exceed 100 km while the length is limited to about 400 km. Thus the range of this species is the most restricted of all the muscicapine, culicicapine and rhipiduran flycatchers occurring in southern India.

Status:

The Black-and-Orange flycatcher is a common bird in the hills of the southern Western Ghats lying between the Biligirirangans and the Ashambu hills, usually above 1500 m msl. It is one of the commonest flycatchers of the genus *Muscicapa* in the upper plateaux of the Nilgiris, the Biligirirangans, Siruvani hills (E.R.C. Davidar Per. Comm.), High Range, the Palnis and High Wavy Mountains and to some extent in the Agastyarmalai. It is rare in the Nelliampathies, around Valparai in the Anaimalais, and in the Chemmunimalai, and uncommon in the major portion of the Agastyarmalai and Ashambu hills. Wherever met this species was sympatric with *Muscicapa tickelliae, M. albicaudata* and sometimes with *M. pallipes. Culicicapa ceylonensis* was sympatric with *M. nigrorufa* throughout the entire range of the latter.

The result of intensive study of 27 pairs and ringing has established that, contrary to the opinion expressed by authors like Baker (1924), Whistler and Kinnear (1932), and Ali & Ripley (1972), *nigrorufa* is absolutely parochial in its habits and is not given to even any local movements. Recently Ali (1977) has accepted the parochiality of the species. Exceptions were observed only in the case of juveniles and unmated individuals; in the former as a dispersal movement, in the latter in search for mates.

Normally *nigrorufa* lives in pairs and is hardly ever seen as a solitary bird. I always met both the members of a pair within 10 m or so of each other.

Table 2 gives the populations of different flycatchers including *nigrorufa*, and two other species which shared its habitat and in many cases had overlapping requirements in the study plots. All these 18 pairs were closely studied for about two years and every pair bred either in the 1975 or 1976 breeding seasons. As I paid regular visits to all the localities the counts of the flycatchers and other birds are presumed to be accurate. Moreover, many of the pairs were recorded from their nests or contents of the nests which were attended by the parents. It is clear from the table that roughly 2.8 hectares supported a pair of *M. nigrorufa* whereas 4.4 h were needed to support a pair of *M. tickelliae*, 9 h for a pair of *M. albicaudata*, 5.3 h for a pair of *Culicicapa ceylonensis*, 6 h for *Rhipidura albogularis* and 10.6 h for *Brachypteryx major. Erithacus brunneus*, a winter migrant from the Himalayas, was never found in pairs. Curiously enough hardly a single female *E. brunneus* was seen in the winter months whereas males were very common (for detail see M.A.R. Khan in press).

HABITAT PREFERENCE

The Black-and-Orange Flycatcher normally prefers sholas above 1500 m msl., few are found in evergreen forest and occasionally in *Eucalyptus* scrub. I rarely saw it in tea, coffee and *Acacia* plantations. All these vegetation types are considered as microhabitats of the species (Plate I), whereas the shola undergrowth and its variations comprise the microhabitats or immediate environment (Plate II).

The microhabitat of *nigrorufa* was determined on the basis of the bird's preference for certain specific places in the sholas. During each visit to a shola I scrutinized the spot where the birds were seen, the surrounding vegetation and the height at which the birds foraged. In the case of birds living in the sholas above 1500 m msl, mostly in the Nilgiris, the microhabitat usually consists of (in the order of dominance) the following: *Psychotria bisulcata, Lasianthus* spp., *Strobilanthes* spp., *Chomelia asiatica, Pogostemon* sp., *Asystys* sp., *Microtropis ovalifolia, Solanum auriculatum, S. robustum, Pilea trinervia, Pouzolzia trinervia, Alsophila latebrosa, Calamus, Bambusa;* seedlings of *Memecylon malabaricum, Garcinia cambogia, Litsea wightii* etc., all below two meters in height. The stragglers included *Toddalia asiatica, Smilax* spp., *Rosa leschenaultii, Rubus ellipticus, Rubus racemosus, Caesalpinia sepiaria* etc., climbers like *Ipomoea* sp., *Argyreia hirsuta, Piper* spp., *Elaeagnus* spp., and *Polygonum chinense. Oxalis* spp., *Hydrocotyle* sp., and *Carex* spp., were the dominant ground cover. The canopy was dominated by *Syzygium* spp., *Michelia* sp., *Ilex* spp., *Vaccinium* spp., *Gordonia obtusa, Ternstroemia gymnanthera, Turpinia cochinchinensis, Glochidion* spp., *Photinia* spp., *Scolopus* sp., *Vernonia monosis, Elaeocarpus* spp., *Ligustrum* spp., *Euonymus* sp., *Macaranga* and *Hydnocarpus alpina* etc.

Where the sholas were close to human habitations or plantations (e.g. sholas around Coonoor and Ooty townships) the canopy layer included a few exotics like *Trema orientalis, Eucalyptus* spp., *Acacia* spp., *Pinus* spp., *Callitris* sp., *Cupressus* spp., and *Grevillia robusta* whereas undergrowth in such areas usually had an abundance of *Solanum* spp., *Cestrum aurantiacum, C. elegans, Tecomaria capensis, Lantana camara, Datura arborea* etc. in addition to the natural shrubs (Plate II).

The microhabitats above 2000 m included more of *Sarcococca trinervia,* all species of *Rubus* occurring in the upper plateau of the Nilgiris, *Mahonia nepaulensis, Berberis tinctoria, Toddalia asiatica, Ulex europaeus, Cytisus scoparious, Rumex, Elaeagnus, Eupatorium glandulosum, Bambusa nana,* and brackens. The canopy had *Arbotus rollisonii, Cinnamomum, Eurya japonica, Rhododendron, Vitex altisima* and *Vitex vitifolia* in addition to the plants already mentioned. Here the canopy height never exceeded 5 meters. The and macro- micro- habitats of *M. nigrorufa* in the Biligirirangans, Upper Plateau of the Nilgiris, possibly Siruvani hills, Munnar (High Range), Kodaikanal (the Palnis), Venniar (High Wavy Mountains) and to some extent the Agastyarmalai were of these types.

The microhabitats in the plantations in the lower plateau of the Nilgiris, the Nelliampathies, Cardamom hills, the Chemmunimalai, the Agastyarmalai and Ashambu hills are mostly dominated by a plentiful undergrowth of *Ochlandra, Pandanus, Calamus* and *Strobilanthes* under stands of *Cullenia, Hopea, Mesua, Cinnamomum, Litsea, Syzygium, Calophyllum* and *Elaeocarpus.*

The microhabitats of the pairs studied and other casually observed were all traversed by at least one perennial stream each, and the flycatcher usually lived within one and half metres of the ground surface, the latter always covered with a thickish litter of leaves.

Considering all the stations I have investigated in the Western Ghats it is apparent that the habitat requirements of the Black-and-Orange Flycatcher are primarily met by the luxuriant undergrowth or thickets of a typical shola; and secondarily by the different types of bushes and shrubbery in the tea-coffee, gum-wattle plantations or in ornamental gardens and private compounds provided these have (1) floor with litter layer of dead and decaying leaves and decomposed plant matter which harbours hordes of insects; streams, brooks or pools, clearings and paths to provide drinking, bathing and feeding places for the flycatchers; (2) Shrubs, seedlings and herbs of suitable heights to provide the flycatcher with shelter, perching and roosting places, and nest sites; (3) Sedge blades, (*Carex* spp.) bamboo, cane and screw-pine leaves, pine needles, climbers and twiners to provide nest materials. Any habitat possessing the above features may be considered as suitable for the Black-and-Orange Flycatcher. Most of the sholas around different places in the upper Nilgiri plateau, Honnametti, Attikan and Bellaji in the Biligirirangan hills; Munnar and Nymakad in the High Range; Bombay shola, Shembaganur, Tiger shola, Berijam and Gundur Valley of Kodaikanal in the Palnis and Venniar of High Wavy Mountains provide the requirements and hence support denser populations of this species than the other areas in the Western Ghats.

FOOD AND FEEDING HABITS

To determine the food of this species emphasis was given to field observation rather than stomach contents. A sample of five birds-one lone male (ringed with BNHS Z-7470) and two pairs (No. 6 & 13)* were selected for intensive field study. As the macrohabitats of these birds were thinned out remnants of erstwhile larger sholas the birds could be observed with less difficulty. Sometimes they could be watched even without the aid of binoculars. In the absence of stomach contents (except what were obtained from two dead specimens), efforts were concentrated on random collection of insects from the territory of Z-7470 by 'sweeping' different portions. A specially made insect net with a mouth of *c* 40 cm in diameter and of 80 cm length was used for this purpose. During November 1974, March and September 1975 the sweeping was done 80 times in each month. Each time the net was swept within 50 cm of the ground level and mostly touching the leaf litter, so as to collect most insects present just above the litter layer where the birds were mostly feeding.

In addition to direct observation and sweeping a third successful though somewhat cruel method was adopted to force the adult birds to drop the food items they had picked up. When a flycatcher caught an insect or larva *c.* 10 mm in length close enough to me, I would scare the bird suddenly, so as to make it drop the food item in fright. In 20 such attempts on five birds half were successful and yielded useful results as will be shown below. Only two stomachs were actually analysed for their contents.

Food:

Apparently the food of *M. nigrorufa* consists mainly of insects belonging to the orders Diptera, Lepidoptera, Coleoptera, Orthoptera, and to a lesser extent of Hymenoptera and Neuroptera, including larvae and nymphs. The insects consumed, in order of prominence in the sample studied, were members of Sepsidae, Chironomidae (midges, blood-worms and eye flies), Stratiomyidae, Tipulidae (*Tipula,* daddylong-leg flies), Noctuidae and Pyralididae (moths), Danaidae and Hesperidae, Pieridae and Papilionidae (butterflies), Culicidae, Ichneumonidae, Tachinidae (bristle flies), Acrididae (nymphs only), Chrysopidae (*Chrysopa*), Asilidae, Muscidae, Chrysomelidae etc. The stomach contents suggest the presence of sepsids, chironomids, stratiomyids, asilids, tipulids etc. The food insects observed directly conform, by and large, with the larger insects included in the above mentioned groups. It was rather difficult to be sure of the flies and other smaller items eaten. The data from the sweepings (Table 3) also support above findings. Moreover, the food items obtained by 'pirating' the adult birds show one caterpillar (*Papilio*), one butterfly (Nilgiri Tiger *Danais nilgiriensis*), two moths (Noctuidae), three daddylong-leg flies (*Tipula*), two grasshopper nymphs (Acrididae) and one earthworm (*Pheretima*). Occasionally they also took leafhoppers (Jassidae).

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* Each of the 27 intensively studied pairs was given a serial number, beginning with 1.

Feeding habits:

Five birds were intensively followed for 175 hrs, of which the birds remained out of sight for 24 hrs when they foraged in the thicker part of the vegetation. Besides watching these five specimens all the remaining pairs (25) were also monitored for appreciable periods for any variations in feeding habits from those observed more closely. This was mainly done during rounds of visits to their habitats.

The flycatchers followed a number of feeding methods. Gaston (1974) and Croxall (1976) have described feeding methods of birds of the genus *Phylloscopus* and of mixed-species hunting parties (bird flocks) respectively. With certain modifications, I have adopted some of their terms in describing the various feeding methods of *nigrorufa*. They are as under:

Sally: Catching insects from litter layer and within about 10 cm above the ground surface. At no time did the birds settle on the bare ground during a sally.

Flycatching: Taking flying insects on the wing either from a perch or from the ground and always between 10 cm and one metre or so above the surface. This also included a few attempts made by the birds to catch butterflies above one metre.

Flitting: Searching for food amongst undergrowth using frequent brief flights. This method of feeding could not be followed easily since for considerable periods the flycatchers foraged inside the thicker part of the vegetation where visibility was greatly impeded.

Hopping: Collecting food from the litter layer by means of hopping. Unlike babblers, the Blue Chat, Rufousbellied Shortwing, and Blackbird this flycatcher did neither scratch amongst the leaf litter nor flick aside any leaves to obtain its food. Rather it just picked from the surface larvae of insects exposed through the activities of the other ground feeding birds.

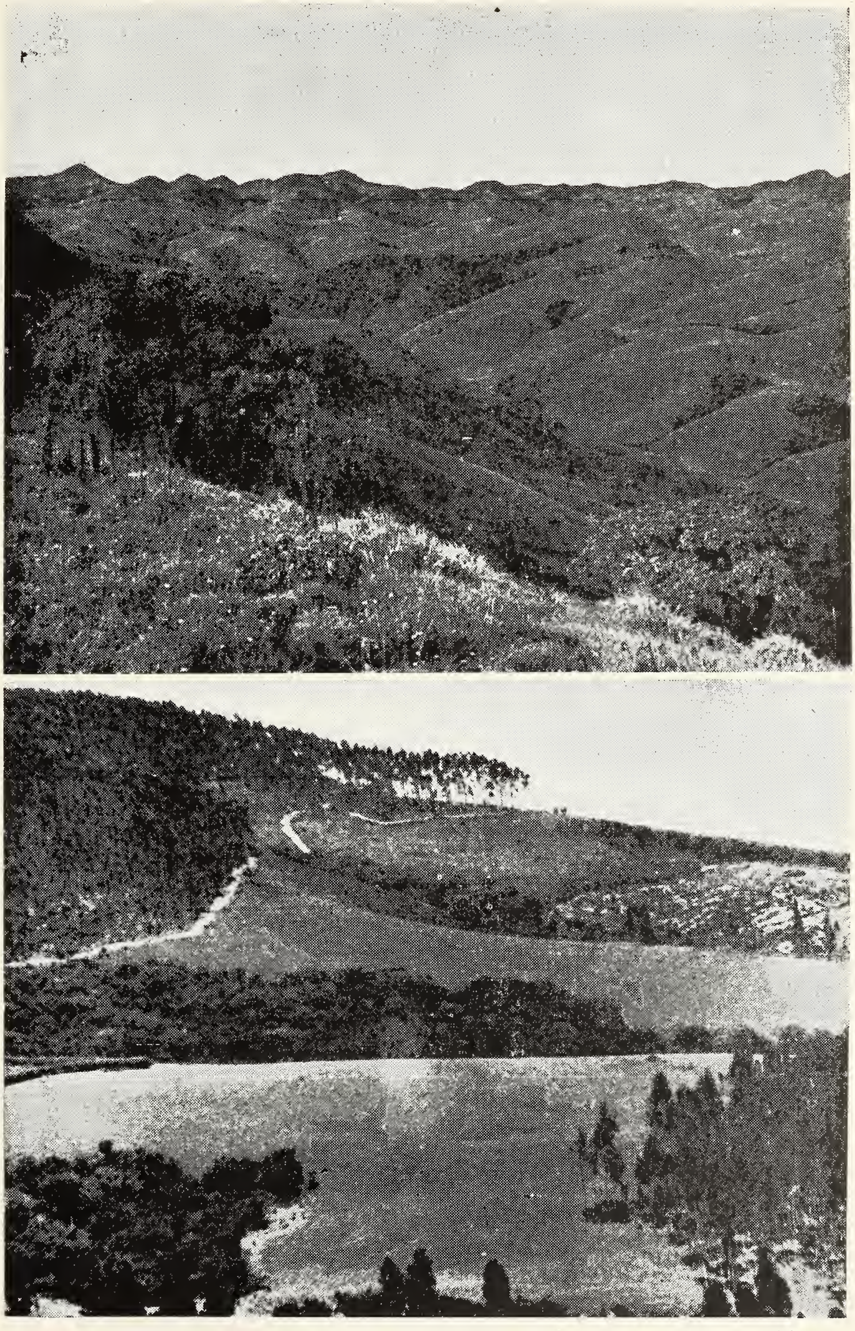
Hovering: Hovering for a very short period, a fraction of a second, to pick up insects or their larvae from the tip of a twig or leaf.

Clinging: Clinging to bark of a tree for collecting insects settled there much in the fashion of a nuthatch.

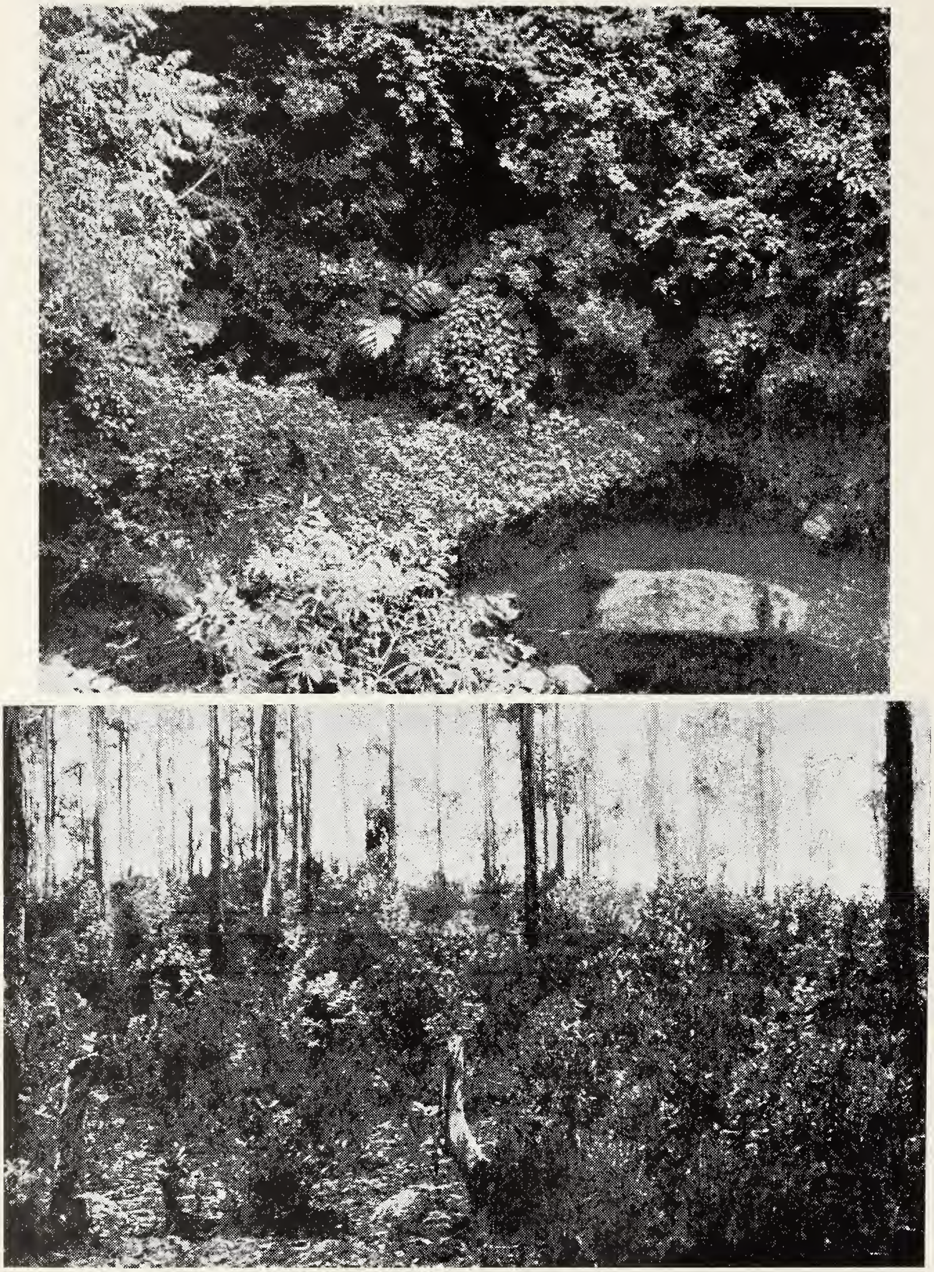
I assumed that in each feeding attempt a bird usually did catch an insect, it always seemed to have a definite target as Hartley (1964) observed in hawking flycatchers. Granting one insect per attempt, the result of close field study has been shown in Table 4. It can be said from the table that the flycatcher ate mostly sepsids, chironomids and other dipterans and hymenopterans by means of sally; and muscids and lepidopterans by flycatching. The flycatcher collected caterpillars, various types of insects and their larvae settled on the foliage by flitting. Hopping helped it to capture midges and nymphs, flies and ants settled on the litter layer or on the ground cover. Hovering facilitated it to collect insect larvae etc., while clinging enabled it to catch jassids from the bark.

The sally was the most common method of capture followed by flycatching. The former comprised 77.40 per cent of the total insect catch while the latter 13.45%. The feeding rate was 73 insects per hour on the average (Table 5). It was 69.5 for Z-7470; 75.4 for male of Pair 13; 69 for Male-6; 78 for Fe-

Reza Khan: *Mucicapa nigrorufa*



Above : The sholas around 2000 metres—perfect *M. nigrorufa* habitat.
Below : A typical microhabitat of *M. nigrorufa*. (Photos : *Author*)



Above : The shola undergrowth a typical microhabitat of *M. nigrorufa* with a stream in the foreground.

Below : Undergrowth of *Eucalyptus* plantation (Nilgiris) with an abundance of *Rhodomyrctus tomentosa.* (Photos : *Author*) male-13 and 73 for Female-6. The feeding rate of the Tickell's Blue (*M. tickelliae*) and Greyheaded (*Culicicapa ceylonensis*) flycatchers appeared to be 65 and 90 insects per hour (based on 180 minutes and 60 min. of observation) respectively.

The lone male Z-7470 was followed for a whole day when it could be effectively observed for 10 hrs and 30 min., between 0645 and 1815 hrs. During the remaining one hour the bird could not be watched as it foraged in the interior of the shrubbery. The rate of feeding per hour ranged from 49 to 103 insects. It was 49 between 1300 and 1400 hrs, 98 between 0700 and 0800 hrs, 100 between 1700 and 1800 hrs, and 103 between 1600 and 1700 hrs. Thus it had atleast two peak hours of feeding, one in the morning the other at the close of the day. The rate of feeding at this period averaged 100 insects and was double the rate at mid-day, which was 49.

Since the microhabitat of the Black-and-Orange Flycatcher is regularly shared by several other species of flycatchers such as Tickell's Blue and Greyheaded, and by other birds like the Blue Chat, Shortwing and babblers there always exists some interspecific competition for food between them. To show this the feeding habits of *nigrorufa* and the four co-existing species have been summarized in Table 6, which has been prepared largely on the model of Croxall (1976).

The Blue Chat (*E. brunneus*), Rufousbellied Shortwing (*B. major*), Spotted Babbler (*Pellorneum ruficeps*) have more or less similar feeding habits. They prefer collecting food, both insects and earthworms, from the leaf litter on the floor. As shown in the above table (6) and mentioned earlier under Feeding Methods, this flycatcher collects its food mostly on the wing either from the ground surface or in the air. While hopping on the ground it often encounters one of these three ground feeding species. The Blue Chat is a winter migrant and sojourns in the Nilgiris from October to March. It spends most of its time on the ground and at least a quarter of the day inside the shrubbery largely resting, preening and soliloquizing. It is parochial, and prefers the edges of the sholas. But because of its altogether different feeding habits it evidently does not compete seriously for food with *nigrorufa*.

The Shortwing is a denizen of the darkest part of the shola or thickest part of the shrubbery in gardens and compounds. It is resident in the Nilgiris. Like the Blue Chat it spends most of its time feeding on the ground, and resting, singing, soliloquizing and preening. The Black-and-Orange Flycatcher hardly has a chance to meet the shortwing since it does not normally visit the darkest parts of the shrubbery. Moreover, shortwings are not so parochial as *nigrorufa*. They wander a great deal therefore, the competition for food between the two is unlikely to be of a serious nature.

The Spotted Babbler, like most others of its kind, seldom lives in the same spot of the shola or of the *nigrorufa* microhabitat. As it does not stick to one spot and forages over a wider area the flycatcher can easily avoid competing with it for food.

However, there is competition for food between the Black-and-Orange and Tickell's Blue flycatchers since many of their feeding habits are similar (Table 6), and in many places their habitats also overlap. But Tickell's is a bird of comparatively open woodlands and not so parochial as the former, it lives over a much wider area than Black-and-Orange, covering a variety of habitats. Thus competition between them is evidently much reduced.

TABLE 1

RECORD OF OCCURRENCE/ABSENCE OF *M. nigrorufa* IN THE WESTERN GHATS

Name of the hills prospected	Time spent in hours	No of pairs seen/heard	Status and remarks
Biligirirangans: Attikan, Bedugali, Bellaji and Honnametti. 900-1730 m. msl.	20i	17 (3) ii	Common, sholas and edges of Coffee plantation, above 1300 m.
Brahmagiris: Rama and Laxmana Tirtha. 700-1400 m.	15	None	Mostly evergreen, very few sholas.
Nilgiris: almost entire upper plateau. 1000-2635 m.	363	209 (8)	Common, in sholas and in Eucalyptus & Tea plantation thickets, above 1500 m.
Nilgiri-Wynaad: 700-1200 m.	9 days in March & 7 days in October, 1977	None	Evergreen and moist deciduous forests.
Kerala-Wynaad: 700-1000 m.	20	None	Mostly evergreen forests.
Siruvani hills: 1700 m.	—	—	Common. Information by Mr. Davidar.
Nelliampathies: Kaikatty, Padagiri & Periasolai, 500-1400 m.	25	2	Rare, between Hilltopmalai and Padagiri Peak, evergreen forest, *c.* 1400 m.
Anaimalais: Top-Slip environs. *c.* 800 m.	15	None	Moist deciduous and evergreen forests.
Pandavarai & other peaks. *c.* 1200 m.	10	None	As in Top-Slip.
Umaiamalai & foot of Perungundur Peak. 1000-1200 m.	10	None	As in Top-Slip.
Parambikulam, Thelical, Vengolimudi & Tunacadavu. 500-1000 m.	30	None	As in Top-Slip.
Valparai (Grass Hill). 1000-1300 m.	20	2	Rare, sholas.

Name of hills prospected	Time Spent in hours	No. of pairs seen heard	Status and remarks
Sholaiyar. 700-1400 m.	5	None	Evergreen forests, and sholas of Karumalaigopuram.
High Range: Nymakad Tea Estate, Munnar & Devikulam environs. 1000-1800 m.	30	22 (2)	Common above 1300 m, none below this elevation, mostly in sholas & Tea Estates. One visit paid by Mr. Sugathan in June 1976.
Cardamom hills: Santhanpara. 900-1120 m.	12	None	Cardamom sholas.
Peermade. 800-1000 m.	10	None	Cardamom sholas, Tea & Coffee plantations.
Kumili and Periyar Wildlife Sanctuary. 800-900 m.	6	None	Evergreen and moist deciduous forests.
High Wavy Mountains: Venniar. 1500-1800 m.	10	10 (4)	Common around typical sholas, few in the thickets of tea.
Palnis: Kodaikanal town panchayat, Berijam, Gundur Valley, Old Coolie ghat road, Tiger sholai, Shembaganur and Perumalmalai. 1000-2200 m.	50	36 (4)	Common, all above 1300 m in sholas, evergreen forests and also in private gardens and plantations.
Chemmunimalai, Bonaccord Tea Estate environs. 900-1300 m.	8	2	Rare, along stream at 1250 m in evergreen forest, amongst *Ochlandra* brakes.
Agastyarmalai: Aduramalai Tea Estate (abandoned). 900-1200 m.	12	4	Rare, amongst *Calamus, Ochlandra* & *Pandanus* brakes of evergreen forests.
Agastyarmudi. 1300-1800 m.	5	5	Not uncommon in the stunted sholas, like the Nilgiris.
Ashambu hills; Kalakkadu, Virapuli in Kakkachi and Kodaiyar Dam area. 900-1200 m.	15	7	Not uncommon amongst *Calamus, Ochlandra & Pandanus,* and other undergrowths of evergreen forests.
Area between Balamore and Muthukuzhi in Azhapandipuram Range. 700-1300 m.	7	1	Rare, at 1300 m in evergreen forest.

i: Covered 1.5 km per hour of trekking.
ii: Unsexed. Each bird may represent one pair.

The Greyheaded Flycatcher (*C. ceylonensis*) captures insect prey mostly by sallies, usually more than a metre off the ground surface, and it rarely descends to the floor. It is not a strictly parochial species either. It lives in a variety of habitats and may be met with also in private compounds. If it ever gets into the proximity of the Black-and-Orange Flycatcher it is invariably chased off by the latter.

The Nilgiri Verditer Flycatcher, though not uncommon, usually prefers the upper canopy where it not only eats insects but also fruits and berries of *Vaccinium, Syzygium, Cestrum* etc. *M. nigorufa* hardly ever visits the canopy, and I have no evidence that this species and the Nilgiri Verditer ever compete for food.

Black-and-Orange Flycatchers usually live in pairs. A third individual was hardly ever seen in the territory of a pair except during the breeding season. Only Z-7470, a lone male, used to visit the territories of neighbouring

TABLE 2

COMPARISON OF POPULATION SIZE OF *Muscicapa nigrorufa* AND OTHER ASSOCIATED SPECIES IN THE SAMPLE STUDY PLOTS IN THE NILGIRIS.

Study plots	i	ii	iii	iv	v	vi	vii
		(see below)					
Botanical Garden (Ooty) *c.* 25 hectares.	5 pairs (Nos. 13, 13A, 13B, 14 & 14A)	2	1	2	3	4 males	1
Sims' Park (Coonoor) 15 h.	3 pairs (9, 10, 11 & lone male Z-7470)	4	2	3	2	5 males 1 female	1
Forest Lodge Shola (Coonoor), *c.* 10 h.	7 pairs (5, 6, 7, 8, 5A, 6A & 8A)	4	2	3	3	7 males	2
Hebron School Shola (Coonoor) *c.* 3 h.	3 pairs (1, 2 & 3)	2	1	2	1	3 males	1

i: Black-and-Orange Flycatcher *Muscicapa nigrorufa*
ii: Tickell's Blue Flycatcher *M. tickelliae*
iii: Nilgiri Verditer Flycatcher *M. albicaudata*
iv: Greyheaded Flycatcher *Culicicapa ceylonensis*
v: Whitespotted Fantail Flycatcher *Rhipidura albogularis*
vi: Indian Blue Chat *Erithacus brunneus*
vii: Rufousbellied Shortwing *Brachypteryx major*

Figures within the parentheses include the pair nos., those with alphabet letters were studied only in 1976 breeding season.

pairs occasionally. Whenever spotted by a territory-owning male he was chased out immediately. Intraspecific competition for food seemed to be a casual affair and there was literally no intrapair competition either.

SUMMARY

The year-long field study, conducted between 1974 and 1976, has revealed that, the Black-and-Orange Flycatcher is not a rare or uncommon bird as earlier regarded; it occurs in the hills lying between the Biligirirangans (Mysore) and Ashambu hills (Kanyakumari) of the Western Ghats; from the northernmost to the southernmost limits it has continuous distribution and is present on either edges of the Palghat Gap; it is one of the commonest of the flycatchers, above 1500 m msl, anywhere in the sholas occurring in the Biligirirangans, the Nilgiris, High Range, the Palnis and the High Wavy Mountains; rather uncommon in the heavy rainfall zones with evergreen forests and totally wanting in the moist-and dry-deciduous forests of the Western Ghats. Its range is the most restricted of all the associated flycatcher species; its microhabitat comprises solely of undergrowth, thickets, shrubbery and bushes of a natural vegetation (mostly the sholas), and to some extent of different plantations around 1500 m; It does not show any local movements and the species is a very parochial one. Its food consists mainly of dipteran, lepidopteran, coleopteran and orthopteran insects which are mostly caught on the wing either by 'sally' or by 'flycatching,' from the ground surface and within one metre of it; although it competes for food with a couple of associated species it has a particular way of avoiding severe competition and hence co-exits with them in the similar habitats.

TABLE 3

RESULTS OF SWEEPINGS FOR INSECTS IN THE TERRITORY OF A MALE Z-7470.

Name of insect group	Number of insects obtained in:		
	May	September	November
	(1975)		(1974)
DIPTERA:			
Sepsidae	127	124	99
Chironomidae	30	12	16
Culicidae	8	10	9
Stratiomyidae	10	3	14
Tipulidae	8	5	3
Asilidae	4	1	2
Unidentified	60	55	49
ORTHOPTERA:			
Acrididae	41	15	32
LEIDOPTERA:			
Pyralididae	15	19	16
Noctuidae	13	3	12
HYMENOPTERA:			
Ichneumonidae	14	3	17
Unidentified	22	11	20
NEUROPTERA:			
Chrysopidae	10	7	—
HEMIPTERA:			
Jassidae	3	4	2
Fulgoridae	1	—	1
COLEOPTERA:			
Chrysomelidae etc.	39	42	28
Total	405	314	320

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TABLE 4

DIFFERENT FEEDING METHODS ADOPTED BY *Muscicapa nigrorufa*

Type of feeding methods	Z-7470 Nov. 1974 70 hrs. observation Feedlng attempts:		Pair 13 March 1975 46 hrs. Feeding attempts:		Pair 6 September1975 35 hrs. Feeding attempt:	
	Number	Per cent	Number Male–Female	Per cent. Male–Female	Number Male–Female	Per cent Male–Female
Sally	4068	83.32	1328-1176	67.75-75.34 (71.51)	1017-887	73.75-80.93 (77.34) mean
Flycatching	570	11.68	396-283	20.20-18.12 (19.16)	198-73	14.36-6.66 (10.51)
Flitting	121	2.48	84-55	4.30-3.51 (3.90)	79-57	5.72-5.20 (5.46)
Hopping	110	2.25	125-39	6.37-2.50 (4.43)	82-75	5.94-6.88 (5.41)
Hovering	9	0.19	19-6	0.97-0.39	0-2	0-0.18
Clinging	4	0.08	8-2	0.40-0.13	3-2	0.22-0.18
Total attempts:	4882		1960-1561		1379-1096	
Average per cent:	Sally 77.40		Flycatching 13.45	Flitting 3.95	Hopping 3.70	Hovering and Clinging c. 1.50

TABLE 5

RATE OF FEEDING OF *Muscicapa nigrorufa*

Birds Observed	No. of hours observed		Rate of feeding/hour		Average rate/hou
	Male	Female	Male	Female	
Z-7470	70	—	69.5	—	
Pair 6	20	15	69.0	73.0	73.0
Pair 13	26	20	75.4	78.0	
Total 5	116	35	71.3	75.5	

TABLE 6

SUMMARY OF FEEDING HABITS OF *Muscicapa nigrorufa* AND OTHERS

Reeding methods	*Muscicapa nigrorufa*	*Muscicapa tickelliae*	*Culicicapa ceylonensis*	*Erithacus brunneus*	*Brachypteryx major*
Prey aerial: Bird aerial. On simple flight from and back to perch i.e., sally and	Most common	Common	Most common [i]	—	—
flycatching	Uncommon	Common	Not uncommon	—	—
Prey aerial: Bird not aerial. Snapping at passing prey from perch	Rare	Rare	?	—	—
Prey stationary: Bird aerial. Hovering.	Rare	Rare	—	—	—
Snatching prey from vegetation while passing	—	Rare	—	—	—
Prey stationary: Bird not aerial. Foraging haphazardly in open vegetation. Hopping	Rare	?		Hopping, Picking & Flicking. *E. brunneus* and *E. major* forage systematically in open vegetation and in undergrowth.	Hopping, Picking & Flicking.
Clinging	Rare	—			
Foraging in dense vegetation	Rare	Rare	Uncommon	Uncommon	Most common

i : *C. ceylonensis* collects insects usually one metre above the ground. Methods like sally, flycatching etc., have already been described.

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RODENT RESEARCH IN INDIA

Ishwar Prakash[1]

I take justifiable pride in the fact that all through my teaching/research career spanning the last two decades it has almost been a habit with me to ensure that the organisation that I might be serving at any particular time must have all the available volumes of *JBNHS* in its library. While I cannot altogether disown selfish motives in being in close physical proximity to the fascinating store of nature lore that the pages of *JBNHS* contain, I can at least claim to nurture, at the same time a sustained interest in the propagation of *JBNHS* for the values that it has upheld all these 75 years. Therefore, when I received an invitation from the Editor to contribute to the 75th Anniversary Volume, I took it as an opportunity to repay my debt to this great journal at least partially. I am presenting a brief account of rodent research that has been carried out in the country during the period since the 50th Volume of *JBNHS* was published.

India's golden period of mammal research was during the early part of this century when an immense volume of material poured out of the press, written by stalwarts of Indian mammalogy. A lucid account of the history of Indian mammalogy has been presented by Kinnear (1952) in the 50th Volume of the *JBNHS*. Pertaining to rodents, probably the most important were the 55 reports of the *BNHS* Mammal Survey incorporating the Scientific Results and Summaries of the survey series, mostly done by Wroughton. After this period, a sort of dormancy prevailed in respect of research work on rodents as well as mammals in our country which was probably broken in 1953 by Professor Daya Krishna of the Jaswant College, Jodhpur, who was awarded a Research Project on Vertebrate Ecology of the Indian Desert by U.N.E.S.C.O. I had the privilege of starting it as the mammalogist. It continued upto 1956. Individually Dr. M. L. Roonwal had already started his monographic work on the mammals of Manipur (1948, 1949, 1950). Later, Indian Council of Agricultural Research (ICAR) established, in 1959, a section on Animal Ecology in the Central Arid Zone Research Institute, Jodhpur, chiefly to study the desert rodents and to find out ways and means to control them. The author has been working in this section since its inception. Simultaneously, ICAR launched a Coordinated Scheme for research on the study of field rats. It lasted till 1969. The Johns Hopkins University started a centre at Calcutta and rodent research was a part of its programme. In 1970 U.S.A.I.D. launched a field programme of rodent control in the Sidhpur *taluka* in Gujarat State and in 1972 the Ford Foundation funded Department of Vertebrate Biology in the University of Agricultural Sciences at Bangalore. Thereafter, ICAR again renewed its interest in Rodent Research, initiating an All India Coordinated Programme on Rodent Research with four centres and by launching a National Programme for Rodent Pest Management in 1975. I am endeavouring to present briefly the salient features of research conducted under the above mentioned projects and a few more centres.

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Central Arid zone Research Institute, Jodhpur

Ecological Survey

An ecological survey of rodent population in a vast region representing the desert biome was conducted and besides reporting 8 rodent species for the first time, district-wise density of rodents, relative abundance, species composition in various habitats, and their inter-relationship with vegetation types, agricultural crops and soil texture have been worked out (Prakash *et al.* 1971). Certain rodent pests show habitat specificity, such as: *Gerbillus n. indus* occurs exclusively in the sandy habitat; *Rattus c. cutchicus* and *Mus cervicolor phillipsi* in the rocky habitat; and *R. meltada pallidior, Golunda ellioti, Nesokia indica, Mus booduga* in the agricultural crops. Our colleague, Shri Rana has just collected *Bandicota bengalensis* and *Vandeleuria o. spadicea* from Bisalpur, from the foot of Aravallis in western Rajasthan.

Food

The rodents feed throughout the year upon vegetative parts of plants, supplemented by seeds (post-monsoon and winter) and insects (spring and summer for *Tatera* and summer for *Meriones*). The fluctuations in the occurrence of various food items were more common in the latter gerbil, which were in conformity with the changing vegetational ecosystem reflecting the availability of different food items. The food preferences of merion gerbil were studied in the field during monsoon by comparing the frequency of occurrence of each plant species in the biotope with that of the un-consumed plant species lying near burrow openings of the gerbils. It was revealed that they show a definite preference for palatable grasses, the preference being in the following order: *Cenchrus ciliaris, Aristida adscenionis, Eragrostis ciliaris, Digitaria adscendens, Brachiaris ramosa* and *Tragus biflorus.* In the desert tract where the study was conducted, the density of desert gerbils was estimated to be 477 per hectare. Considering that a gerbil consumes about 6 gm. feed a day, their annual requirement will be 1044 kg/hectare assuming that their number will be maintained at this level all the year round. The figure of the estimated forage production in this tract were 1410 per hectare. Comparing this figure it will appear that hardly any fodder will be left for livestock, particularly when the estimate of the gerbil depradation does not include the destruction they do by cutting the grasses and by digging burrows in the root systems of plants. The gerbils do serious damage to tree plantations by their debarking activity. Sometimes the debarking is done so deep that the system is completely cut causing the death of the tree. Worst affected by the debarking activity of gerbils are *Prosopis spicigera, Albizzia lebbek* and *Acacia tortilis.* They are extremely destructive to the afforestation saplings (Prakash 1975).

The gerbils are also serious factors of desertification as they excavate the stabilised soil at a rate of 61,500 kg/day/km.^{2}

Breeding season

Most of the rodents breed all the year round with peak littering activity in February, monsoon season and November. Minimum breeding activity was, however, observed during April and May. These studies indicate that if rodent control is to be carried out through poison baits, the operations should be taken up during the period of minimum breeding activity (April and May), whereas if gassing is to be followed, the period of maximum littering (monsoon season) should be chosen.

Population characteristics

Detailed studies on population have been made only on *M. hurrianae* and *F. pennanti*. The average annual number of *M. hurrianae* varied from 31 to 456 per 95 × 95 m experimental plots in three bio-climatic zones of Rajasthan desert. The fluctuations in their number also show an annual trend, numbers being lowest in summer and highest in winter and spring, the increase being attributed chiefly to the enhanced rate of reproduction after monsoon as directly influenced by the availability of green food at this time. Number of desert gerbils have a direct relationship with soil characteristics, the population being thinner in clayey and compact soils. An inverse relationship was, however, found between grass cover and population density of desert gerbils (Prakash 1976). The lowest populations of palm squirrel were observed during winter, at which time they do not breed as well. This may be the correct season for their control.

Home Ranges

The average home range of male and female *F. pennanti* was found by minimum home range method to be 0.21 ± 0.73 hectares and 0.15 ± 0.034 hectares respectively. The observed range length of adult male palm squirrel was 65.61 ± 4.80 m., for adult female 46.87 ± 5.40 m., for sub-adult male 41.71 ± 10.93 m, and for sub-adult female 43.95 ± 1.85 m. The observed range length of adult males is more than other groups probably because of higher competition among adult males for mate which are lesser in number than the former. The observed range length of male and female desert gerbil was found to be 16.03 ± 0.98 m and 18.46 ± 1.5 m. Work on *T. indica* is in progress. These studies have shown that the baiting stations for the control of *F. pennanti* and *M. hurrianae* should be established at an interval of 30 m and 10 m respectively.

The behavioural patterns of various rodents, *R. rattus, Gerbillus nanus* and *M. hurrianae* have been extensively studied. This work has clearly indicated a development of a parallel evolution of behavioural adaptations to xeric environment irrespective of geographic discontinuity in the distribution of rodent species (Prakash 1975). The study of humoral aspects has also provided pertinent and useful information regarding the timing of poisoning, bait placement and planning of the operation. Two experiments are in progress since the beginning of the project on exploratory and neophobic behaviour of rodents. The experiments are being done inside the 'plus' maze. Studies on physiological adaptations of the rodents for survival in the desert biome are incorporated in Prakash and Ghosh (1975).

Studies on the ventral marking gland are in progress. The most common use of the secretion of mid ventral gland is for marking around the entrance of burrows and for marking the trails that gerbils use to move about to many burrows. The marking frequency in adult males (median marking score: 8, range 0.27) were greater than adult female (median marking score: 0, range 0.27). Marking rate is greater in 'dominant' male gerbil than that of 'submissive' male gerbil. Efforts are being made to enhance the consumption of poison bait to increase the efficacy of control operation.

In addition to this work, bait preference of 7 species of rodents, bait shyness and lethal dosages of rodenticides for almost all the desert rodents have been worked out (Fitzwater and Prakash 1978). In this review the work on rodent control aspects has been excluded.

CAZRI has been designated as the ICAR Centre for Rodent Research and Training and is also functioning as the Coordinating Unit of the National Programme for Rodent Pest Management since it was launched during 1975 (Prakash 1976).

ICAR Coordinated Scheme on Field Rats

The Coordinated Scheme on the study of field rats, financed by ICAR, ran for 11 years (1959-69) at five centres—Kanpur, Ludhiana, Bombay, Hyderabad and Aduthurai. The major findings have been adapted from Srivastava (1968, 1969).

Species Composition

Trapping results indicated that in Uttar Pradesh, Punjab and near Madras *Bandicota bengalensis, Rattus meltada pallidior, Tatera indica* and *Nesokia indica* are the predominant field rodent species. *Rattus r. rufescens* was also reported in the coconut crops in Marutera in Andhra Pradesh. In Maharashtra, *B. bengalensis, R. rattus, Mus cervicolor nagarum* and *Bandicota indica* were found to be the major species. Probably in the absence of a set pattern of trapping it is not possible to work out the relative abundance of these species from the data. Srivastava (1968) estimated the field rat population of Uttar Pradesh fluctuating between 287 to 818 millions during various months of the year! At Rajendranagar, traps were set near coconut trees and the population of field rats varied from 3 to 8 per acre (= 7 to 19/ha) from October 67 to June 1968.

Damage assessment

Probably the best work done under the scheme was on this aspect and damages were assessed on statistically designed methods. The losses to various crops in the five regions of the scheme are averaged as under: Wheat 11.1 to 11.9 per cent, Barley 5.8 per cent, Jowar 5.8 to 6.3 per cent, Gram 0.9 per cent, Paddy 4.6 to 5.4 per cent, Groundnut 4.1 to 25.8 per cent, Coconut 5 per cent, Maize 14 per cent and sugarcane 2.2 per cent. Besides these major crops, damages to several other crops were also estimated in field particularly in south India.

Habits

Fair attention was paid by the research workers in the scheme on burrow pattern, number, size, shape and colour of faecal pellets. On the basis of patterns of 10 burrows of each species, Srivastava (1968) found that on an average there are 11.9, 7.2 and 4.2 openings in the burrows of *B. bengalensis, T. indica* and *Mus b. booduga,* and are 73.8, 100.5, 35.7 cms. deep respectively. Almost similar results were reported from various other centres. It would have been of interest if such a massive effort of digging about 10,000 burrows in various parts of the country had presented common burrow patterns of various species as has now been done by Barnett & Prakash (1975). Likewise, the extensive work on faecal pellets, paw marks, swimming habits and movements carried out at all the centres could not be used for practical application and yielded conclusion like, “Field observations indicated that the rats migrated from one field to another”, or, “Mole rats when caged together started quarrelling with each other” and so on!

Breeding Season

Breeding data collected over 11 years and at 5 centres pointed out that most of the rodents breed all the year round and their litter size varies from 1 to 16, in *B. bengalensis* at Aduthurai, and 3-9 of *R. meltada.* In Uttar Pradesh *M. b. booduga* was found to litter in the months of September, October, February and June and the litter size ranged from 6 to 13. During February to May and July to October each female of *Rattus meltada* produced 1 to

4 litters, each having 1 to 8 young (av. 3.4), (Srivastava 1968). This information appears to have been collected from random samples excavated out of the burrow and probably a monthly catch on a regular pattern was not planned to yield concrete data on the reproduction activity of rodents.

Punjab Agricultural University, Ludhiana

After the termination of the Scheme, the Punjab Agricultural University continued rodent research and a number of students have submitted their M.Sc. and Ph.D. dissertations on Punjab rodents. The major fields of their investigations have been the rodent-crop relationship, their food, breeding habits, population fluctuations, behaviour of *B. bengalensis, T. indica, R. meltada* and *Mus* spp. Bindra & Sagar (1975) have summarised the result of their work carried out during 1964-1972. A useful compendium has been produced by Sood & Guraya (1976). The University continues to be a centre of an ICAR Coordinated Project, a rodent research initiated in 1977.

John's Hopkins University Medical Research & Training Centre, Calcutta

One of the aspects of study at this Centre was rodents and extensive studies were done on *B. bengalensis* in godowns. Though this bandicoot is a field rodent but in the environs of Calcutta and Bombay, it has more or less taken the niche of *Rattus rattus,* and has replaced it almost totally at the former place. Parrack (1966) and Spillett (1968) found that population of *B. bengalensis* in grain storage godowns over an 11 month period was on an average 0.78 per m^2 of floor space. This appears to be very high figure but Spillett mentioned that these estimates were low. The high population is maintained partly due to their continuous reproductive activity. The prevalence of pregnancy for sexually mature females was the highest that has been recorded for a murid population. The mean number of embryos per pregnant female was 6.2. Spillett calculated the mean annual production of young per adult female as 70. The rate of food consumption by bandicoots led the author to calculate food losses due to rats in a typical Calcutta godown to approximately 4,200 kg annually. The Centre was closed subsequent to these studies.

Central Food Technological Research Institute, Mysore

With a major objective to control the rodent pests, the Central Food Technological Research Institute has also carried out valuable work on rodents particularly in the large ratteries, a facility available till recently only to scientists at this Institute. Besides work on food preferences, burrow patterns, behaviour of rodents, population studies, a number of rodenticides have been screened and a few rodent control methodologies have been developed by the scientists of the Institute.

Indian Grain Storage Institute, Hapur

Rodent work at the Grain Storage Research Institute has been carried out in rural environment. Krishnamurthy *et al.* (1967) observed that the population of house rats in the villages around Hapur was on an average 1,057 rats per village, 9.7 per house and 1.3 per person. In improved residential premises, the rat population was only 1.8 per house and 0.34 per person. Later on, however, Krishnamurthy *et al.* (1971) found the density of rats to be 8.5 to 18.5 per house. The authors observed that the average food intake of *R. rattus* varied with their body weight and ranged from 8.98 to 18.69 g wheat per day, *Mus musculus* consumed 2.56 g/day and *B. bengalensis* 50-60 g. The losses of foodgrains in the village were estimated to range from 1.36 to 3.59 tonnes, average being 2.34 tonnes annually. Another study (Girish *et al.* 1972) calculated that 1 to 3.75 per cent stored foodgrains are lost to rats in city godowns. Besides these studies, work is continuing in the Institute on the efficacy of rodenticides for rodent control. A good compendium has been produced by Pingale *et al.* (1967).

Rodent Control Project, Sidhpur

The work was initiated as an operational research project in the Sidhpur *taluka* of northern Gujarat (80 villages) and one or two villages in every district of the State. Control operation was taken up in residential premises on such a large and successful manner, that the classic work will remain as a demonstration for the entire country if not for the whole world. The villages were maintained at a very low level of rodent population for a long duration (1971-77). Rodent Control Training to State/district/village level workers was another major function of the project. Besides a number of research projects on their population in villages, bait preferences, efficacy of traps and rodenticides, the detailed results are embodied in Ahmedabad Symposium, ably arranged by the project.

Haffkine's Institute, Bombay

In addition to epidemeological studies on Bombay rodents, a great deal of research has been carried out on population change over of species and their control (Deoras 1966).

University of Agricultural Sciences, Bangalore

A department of Vertebrate Biology functioned at the University for five years and it is continued now as a Centre of Coordinated Research Programme on Rodent Control of the ICAR. The research work here continues on rodent species composition in fields, population dynamics, behaviour, bait preferences, evaluation of rodenticides and operational control methods in field.

Aligarh Muslim University, Aligarh

Most of the research work is continuing on *Rattus rattus* on its food habits, bait preference and bait shyness.

Delhi University, Delhi

After completing work on the Indian gerbil and the squirrels at Bangalore, Dr. M. R. N. Prasad migrated to the Delhi University and along with his colleagues has done intensive work on *F. pennanti* and *Nesokia indica.*

Zoological Survey of India, Calcutta

The Zoological Survey of India can claim the credit for the publication of the Fauna of India series, particularly the two volumes on rodents (Ellerman 1961). Biswas & Tiwari (1966) compiled the latest information on the distribution of rodents in India and Agrawal (1962) published the results of his studies on the skulls of oriental rodents. At present, besides taxonomic work, ecological work on rodents is also continuing in ZSI.

National Institute of Communicable Diseases, Delhi

To elucidate the factors responsible for the persistence of plague in the South India plague focus, the Institute has been conducting studies since 1964 mainly to investigate on the wild rodent plague reservoirs. In addition to epidemiological and serological studies on field rodents, studies have yielded excellent data on the population and breeding biology of *Rattus rattus, R. meltada, Mus platythrix* and *Tatera indica hardwickei* (Chandrahas 1974).

Sri Venkateswara University, Tirupati

A survey of rodent infested areas revealed *B. bengalensis*, *R. rattus*, *M. booduga*, *R. meltada* and *T. indica* as predominant pest species around Tirupati. A detailed ecological work on *M. booduga* was undertaken (Rao 1977). The field mice are solitary burrowers occurring in both dry and wet crop habitats and maintaining a congenial microclimate inside the burrows in all seasons. The preferred food of these mice is seeds of various grasses, roots and leaves of Graminae in summer. A seasonal trend of reproduction from August to February is noted. Behaviour of *M. booduga* and *M. platythrix* has been studied in detail.

Symposia, Summer Institutes and Workshops

At least three internationally attended symposia have taken place which were devoted only to rodents. First one at Calcutta in 1966, arranged by Dwain Parrack of the Johns Hopkins University Centre, the second one at Kanpur by Dr. A. S. Srivastava of the State Department of Entomology in 1968 and lastly at Ahmedabad in 1975, Sidhpur. Proceedings of all the three are still available, though that of the first is hard to get.

ICAR has arranged two Summer Institutes one at UAS, Bangalore and the other at CAZRI, Jodhpur with the main objective of training University, Plant Protection Staff and other Officers for conducting Rodent Research. ICAR has planned to hold workshops regularly to evaluate, coordinate and monitor the rodent research in the country. Latest workshop was held at CAZRI in July, 1978.

In spite of the fact that the history of rodent research in India is fairly old yet, as usual for any scientific field, many obvious questions remain to be answered. We have tried to catalogue them in detail (Barnett & Prakash 1975 and Prakash & Ghosh 1975). There is an urgent need of conducting an ecological survey of field rodents in various habitats of the country. How astonishing is that we just do not know for definite which is the rodent species associated with bamboo flowering in Mizoram? What is the relative abundance of various species in Rayalaseema or Kashmir? What are their population and breeding cycles in various bio-climatic zones? and so on. If we accumulate this knowledge, I am sure we will be able to do a much superior job for the National Programme for Rodent Pest Management.

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PROTO-FIDDLERS AND FIDDLERS: PATHWAYS TO WAVING IN INDIAN BRACHYURAN CRABS[1]

RUDOLF ALTEVOGT[2]

(*With four text-figures*)

The visual signalling gestures of the brachyuran crabs *Macrophthalmus tomentosus,* Souleyet (Grapsidae), *Dotilla blanfordi* and *D. myctiroides* (Ocypodidae, Scopimerinae) are described and analyzed by cinematography. In comparison with the waving of true fiddler crabs (genus *Uca,* Ocypodidae, Ocypodinae) one finds an ascending series of complexity in these communication signals so that the said crabs may serve as examples of evolutionary pathways to waving.

Almost a century ago, Alcock (1892, 1902) gave the first account on Indian fiddler crabs which he had observed in the field on the banks of the Godavari and Kistna rivers. Almost twentyfive years ago, I published "some studies on two species of Indian fiddler crabs, *Uca marionis nitidus* Dana and *U. annulipes* Latr." (1955) in the very Journal which we are celebrating by the present diamond jubilee volume. Since then quite a bulk of information has been obtained on the systematics, behavioural ecology and physiology of these most highly evolved brachyuran Crustaceans (for literature upto 1974 see the veritable "bible" on fiddler crabs by Crane, 1975). From the findings of a hoard of enthusiastic Uca-students and scholars quoted in the monumental volume by Crane and other sources listed below, it can safely be concluded that

1) the name giving visual gesture (fiddling, beckoning, waving the great claw by the males) serves semantic purposes informing the conspecific rival to keep away and the potential sex partner to feel appeased and willing to mate,

2) there is a graded series of complexity in the type of waving in the ninety-odd species of true fiddlers of the genus *Uca* reaching from a primitive up-and-down movement of the claw (as in *Uca batuenta* from South America, Altevogt and Altevogt, 1967a) to the extraordinary rotation waving (as in *Uca insignis* from the Eastern Pacific, Altevogt and Altevogt 1967b),

3) that corresponding homologous vibratory signals are produced by tapping claws or legs against the soil when underground in the crabs' burrows at night or under dense vegetation obstructing visual signalling.

While the intriguing wealth of various types and levels of waving in the true fiddlers has attracted numerous authors (including a good number of my students:
Von Hagen 1962; Gunther 1963; Nosler 1963; Korte 1966; Feest 1969; Jansen 1970; Heinrich 1971), the evolutionary prestages of true waving in the lower ranks of Crustacea have little been worked upon (though some hints to and considerations of this phenomenon can already be found in Altevogt, 1957a, b). Also Schone & Schone (1963) as well as Wright (1968) have

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[1] On the 70th anniversary of Prof. Harald Stumpke, alias Gerolf Steiner in Mairuwilli, Black Forest.

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dwelt on this subject. It is for this reason that in the following pages some Indian proto-fiddlers shall be treated and compared to some true fiddlers of India. The relevant data were recorded on several trips to crab habitats along the Indian coasts from north of Bombay down to Cape Comorin and up to Diamond Harbour/Calcutta during the years 1970-1976. Recording was done by cinematography (24-64 frames per second, Bolex H 16 reflex, 16 mm, Ektachrome), and still photography. Thanks are due to Professor Dr. H. O. von Hagen, Marburg, for determining the Macrophthalmus species, and to Miss M. Hans for frame-to-frame analysis and drawing.

From my selected list of proto- and true fiddlers, undoubtedly *Macrophthalmus tomentosus* (earlier known as Mareotis), Souleyet (Grapsidae), belongs to the most primitive fiddlers, followed in ascending order by the two *Dotilla*-species *D. blanfordi and D. myctiroides* (Ocypodidae, Scopimerinae) and the true fiddlers of the *Uca*-type of which *U. urvillei* will be dealt with here. The latter was chosen because its waving type and display are among the simplest and they have so far not been treated in detail (A rough sketch of waving in *Uca urvillei* from Inhaca Island, Mozambique, was given by Mcnae and Kalk, 1958, and Crane, 1975, reports observations from Tanzania and data taken from films on two individuals during August).

Waving in **Macrophthalmus tomentosus**

This is a rather slow affair compared to the real thing in a true fiddler of a somewhat high evolutionary level as, for instance, *Uca annulipes* (see Altevogt 1955, 1957a, and film 1957). From my movie scenes taken in February/March 1976 near Adyar/Madras we find that in *Macrophthalmus tomentosus* the average waving gesture lasts 2.4 seconds (n = 18). From the resting position of the two claws in front of the body and close to the ground, the signalling gesture starts by an asynchronous movement of one claw (see fig. 1, frame 12), thus giving way to an upward movement of the other one (frames 17 to 28). Meanwhile, also the other claw performs a lifting motion (frames 28 to 33). In reaching the apex, both claws catch up with each other so that in the highest position both claws are fully stretched out above the crab's body (frame 39). Lowering the raised claws to the ground and bringing them back to the resting position in front of the mouthparts complete the waving gesture (frames 44-54). It is, then, primarily a vertical wave.

We must note, however, that the temporal pattern of lifting and then lowering the chelae shows an important feature in the 3 to 5 jerks in the raising, while no such intermittent short stops are found in the downward movement. Hence, the conspicuous element in the whole gesture rests in the downward stroke (a finding similar to that in *Dotilla blanfordi*—see Altevogt, 1957b—and to *Dotilla myctiroides*, see below, and to that in many Uca signallings). While on the average the jerking upward movement lasts 2 seconds, the downward emphasis takes only a flash of 0.4 seconds. We have not seen much alteration of this temporal pattern even when a female or male conspecific was close by. This fact may also be taken as a criterion of primitivity, as in true fiddlers the rate and type of waving become more rapid and complex if a prospective sex partner approaches (see Von Hagen, 1962, 1968, and the films by Altevogt and Von Hagen, listed in the appendix). Moreover, in advanced stages of courtship (i.e., higher excitation levels) of most *Uca*-species, the ambulatories are lifted off the ground in a species-specific manner and take part in the

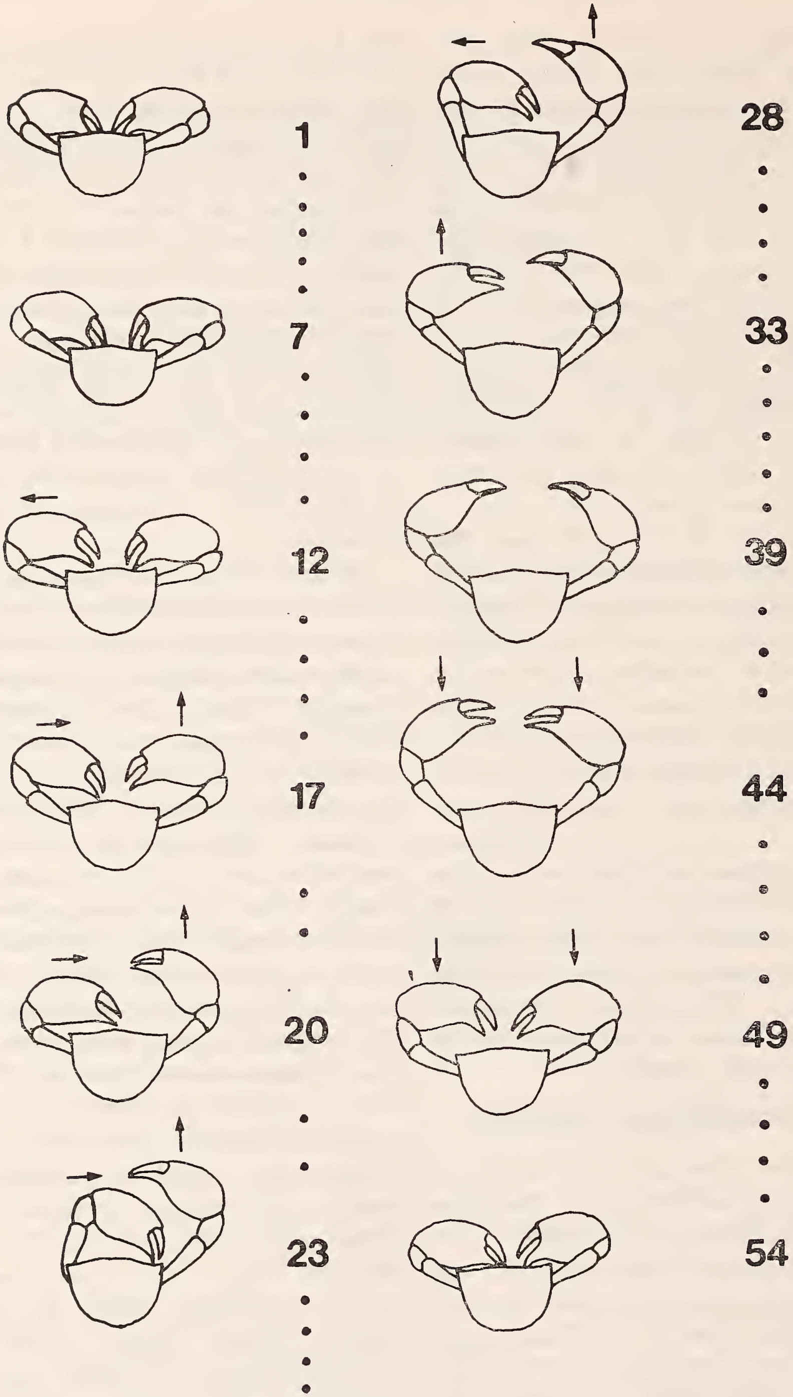
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Fig. 1. Waving in *Macrophthalmus tomentosus*, dorsal view. Numbers and dots represent frame number of movie (24 frames per second).

signalling. No leg raising as in *Uca annulipes, insignis* and others was seen in about 50 individuals of *Macrophthalmus* observed in various stages of excitement. These findings suggest that waving is derived from a locomotory movement because in *Macrophthalmus,* where nature has presented us with a prefabricated slow motion example, the movements of the claws are not at all synchronous at the start, but follow the ancestral style of activating the ambulatories (and the chelipeds as derived walking legs, too) in a crosswise manner. Hence, the waving gesture starts with one claw (see also Altevogt 1972, p. 459 ff.). Incidentally, Crane hypothesized that the vertical wave (as in *Macrophthalmus*) originated from a feeding movement (as in a mud sifting *Uca*-species) while the horizontal wave of several *Uca*-forms would have derived from a threatening gesture in which the claw as a fighting weapon would be shown (1975, p. 523/524 and fig. 87). Earlier, Hediger (1933) had advanced similar ideas about the common root of threatening and waving. It should be noted here that in *Macrophthalmus* both claws are very much similar, if not equal in size.

While in a non-waving *Macrophthalmus* the claws are drab earthen-coloured they tend to become whitish in a signalling animal. This also would be more compatible with a sex-attractant function than with a threatening gesture. In a *Macrophthalmus*-species from Port Swettenham (Malaysia), probably *M. pacificus* Dana, Tweedie (1954) reported bright blue claws and has seen them performing waving movements with both chelae. We have not seen any copulations in *Macrophthalmus* so that the connection between waving and sexual success remains still to be shown (though it is strongly to be inferred from a bulk of findings in other Crustacea Brachyura).

Waving in **Dotilla myctiroides**

While the waving pattern of *Dotilla blanfordi* had been analyzed by frame-to-frame-studies in 1955 (Altevogt 1957b), the typical gesture of *D. myctiroides* had not been covered. The present data were recorded near Panjim (Goa) and Adyar/Madras from February to April 1976.

There are two types of claw movements in *Dotilla* which may easily be confounded by the inexperienced observer: a) the “dance of triumph” after a mock or real fight against an opponent (described in detail for *D. blanfordi* in Altevogt, 1957 a and b) the courtship wave which is, among others, recognizable by the conspicuously bleached chelae. While these are dull brownish-grey in the non-sexual animal they become bluish-white in the sexually aroused male (photograph in Altevogt, 1957b, p. 386). Only the latter type will be dealt with here.

Similarly to the waving in *Macrophthalmus* described above, in *Dotilla myctiroides* the downward component is the most emphasised element of the gesture lasting only 0.08 seconds, while the lifting movement takes 0.13 seconds (averaged from 22 waves in 20 specimens). As can be seen from figure 2 (lower graph), waving gestures follow one another at intervals of 0.17 seconds on the average with a shortest recorded interval of 0.13 seconds. This is slightly superior than the temporal pattern of the *D. blanfordi*-wave where the shortest interval is about the same, but lifting the claw lasts slightly longer (> 0.17 sec), which also applies to the lowering it in the downbeat (about 0.1 seconds).

The spatial components of the *myctiroides*-wave resemble those of the *blanfordi*-gesture and may be seen in fig. 2, upper graph. It should be noted that in both species the claws'

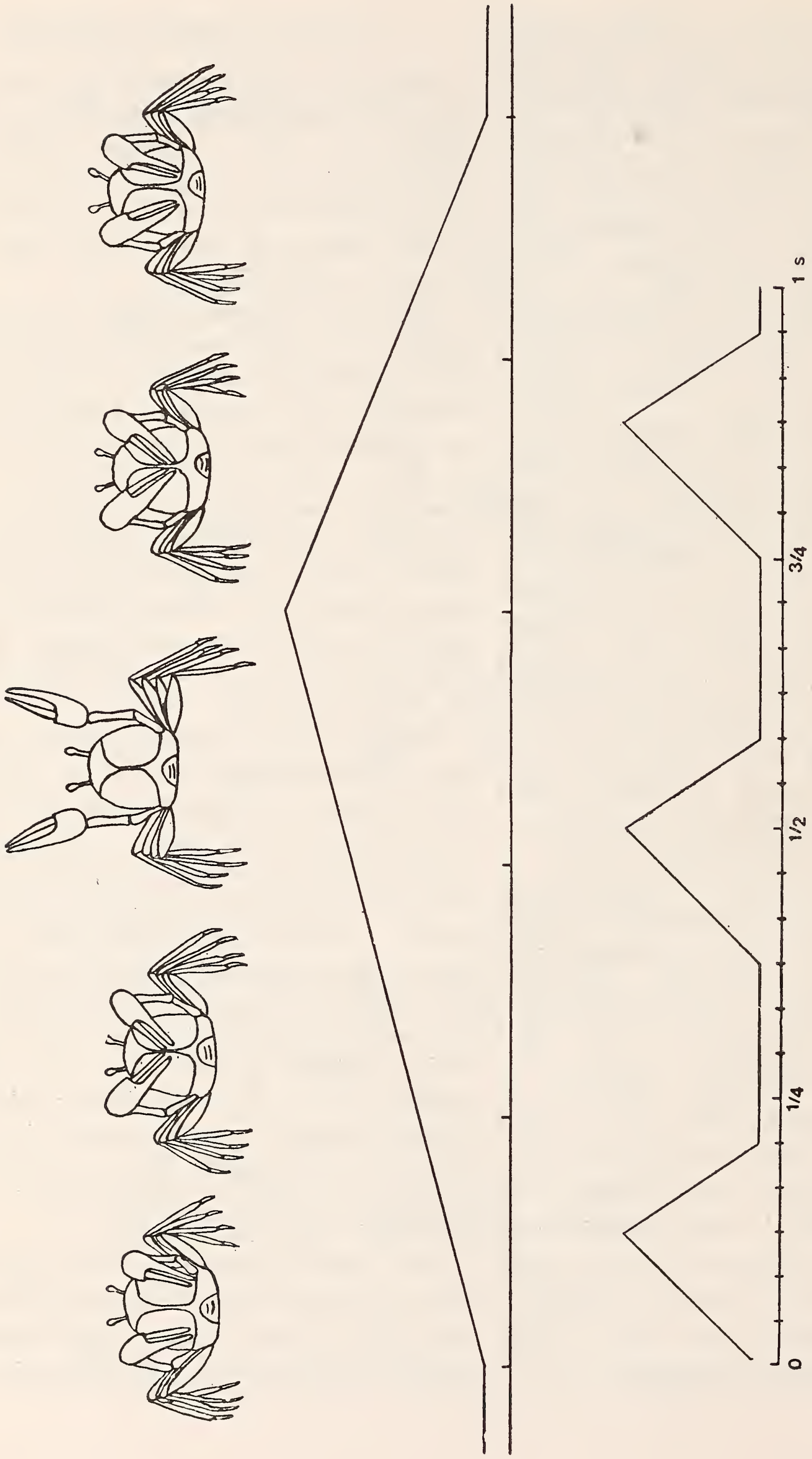

Fig. 2. Waving in *Dotilla myctiroides*, frontal view. Time Scale: 1/24 second.

upward movement is accompanied by a body raising on tip-toes on stretching legs, thus rendering the signalling even more conspicuous. Our recordings at 64 frames per second do not reveal any asynchronous movements of one claw or the other: both claws seem to start synchronously. Possibly, an increased slow-motion technique might reveal an ancestral alternating activation of one claw followed by that of the other one. In any case it becomes clear from the above facts that *Dotilla* has ascended a higher evolutionary ladder than *Macrophthalmus* as far as waving is concerned. In this context it is interesting to quote from a letter by Tweedie (1957) regarding the alternating or simultaneous use of the chelae in *D. myctiroides*: "I think I am right in my observation that *D. m.* uses its chelae both simultaneously and alternately". The situation in the realm of *Uca* must be considered separately, because the tendency of occupying a habitat by more than one often closely related or similar species is so prominent among these true fiddlers that strong evolutionary pressures may be expected to act on the mechanisms of species recognition and individual acquaintance: we have come across mud banks in the gulf of Guayaquil (Ecuador) where a 10 × 10 m square is inhabited by no less than 18 species of *Uca* in which interspecific recognition mechanisms are evident (Von Hagen 1968; Altevogt 1969, films 1967).

Waving in **Uca urvillei**

There is not much information in the literature about the behavioural ecology of this large steel-blue species (carapace width upto 36 mm) the most extensive report being that by Crane (1975). Hence, the following notes may also be taken as an addition to Crane's data (1975, pp. 58-61, table 19). Our findings are mainly based on fieldnotes and movies of 50 waves taken on the islands of Vypeen and Vallarpadam in the Bay of Cochin during March and in Goa (near Panaji) in April. Ovigerous females were numerous indicating that the mating season was in full swing. Nevertheless, waving by the males remained a slow affair indeed, and I know of no other true fiddler of such pronounced lethargy. Thus, the statement by Crane (1975) will remain valid: "Waving display among the simplest" (p. 59). As can be seen from fig. 3, the wave consists of a plain up-and-down of the claw in front of the body with a highest elevation just above the tip of the eyes. No body raise by leg stretching could be seen though in the frequent waving-cum-locomotion such a tip-toeing might seem to occur. That quite frequently waving is performed while marching may be taken as an indication for the still close neurophysiological correlation of walking legs and chelipeds (see Altevogt 1972) also suggesting that *U. urvillei* must be placed on a rather low phyletic scale. From fig. 3 the temporal components of the *urvillei*-wave at the highest arousal level can be seen lasting about 0.5 seconds in the upstroke and 0.17 seconds for the downstroke, making one complete wave last 0.67 seconds. This is slightly shorter than the 0.75 to 0.88 seconds mentioned by Crane (l.c.) and is probably attributable to the fact that in Crane's observations (in August/September) the peak of the mating season was not covered. As far as arousal stages are concerned (see Von Hagen, 1962), our courting males showed definite claw bleaching, with pollex and dactylus clear white and the manus sometimes included in this process. In most of the females also the two small claws became conspicuously white with advancing ebb tide. While Crane could not observe any copulations (apart from pseudocopulatory coverings of females by males),

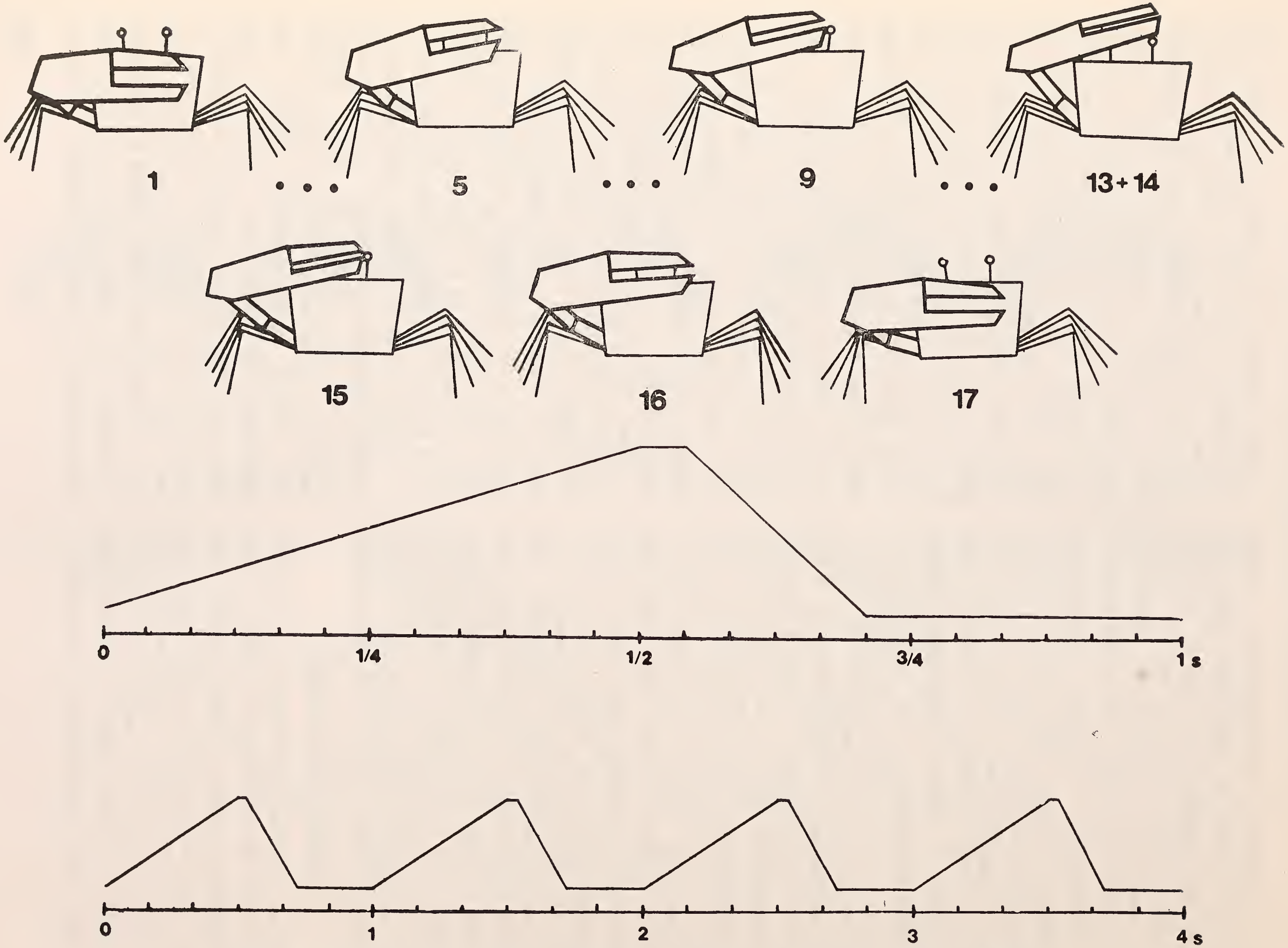
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Fig. 3. Waving in *Uca urvillei,* frontal view. Numbers and dots in upper two lines represent frame number of movie (24 frames per second)—Time scale in lower two lines: 1/24 second.

during our study true copulations (above ground) were quite numerous lasting from 3 to 11 minutes. Some copulations were not preceded by any waving or precopulatory behaviour at all. Normally, though, about 7-11 waves in one series would be aimed at the receptive female, while in a non-courtship display such series consist only of 3 to 4 (as also mentioned by Crane).

It seems worthwhile to briefly compare the waving pattern of *U. urvillei* to that of *U. vocans* (formerly known as *U. marionis*, Holthuis, 1959), as both species are of about the same size and in some places the two species are sympatric (as in Goa and the Cochin region). As reported earlier (Altevogt, 1955, 1957, 1958, 1959), the wave in *U. vocans* follows the temporal and spatial patterns presented in fig. 4.

In both species the upstroke lasts longer than the downstroke, and it is the downstroke which carries the signal "potent male ready to copulate". Now, this informative element would be similar if not identical in both these species if it were not preceded by a different outward flexion angle of the great claw: in *urvillei* the claw is never flexed outward-laterally (see graphic presentation in fig. 3) while in *vocans* the claw's tip is raised high above the eye by a lateral-outward flexion. Moreover, in *vocans* the apex of a wave is emphasised by a body raise on tiptoe, which in *urvillei* was never seen. In *urvillei*, on the other hand, the apex, i.e., the highest position of the claw in the wave, seems to be more pronounced than in *vocans* which shows up in the graphic presentation of fig. 3 in that at this moment the claw is held for a short while (about 0.04 sec). Hence, in spite of all similarities in the timing of the two waves there are certain specific distinctions which undoubtedly serve the conspecific recognition in sympatric encounters.

This recognition of the conspecific sex partner is aided by the typical male waving dance around the female with the male's bleached back facing her. Such a crescendo is absent in *urvillei* so that also from this point of view *urvillei* must be placed between the proto-fiddlers and *Uca vocans* and the more highly evolved true fiddlers.

By the above remarks we hope to have related some examples of proto-fiddlers and lower true fiddlers by which evolution might have ascended to that high level of diversity

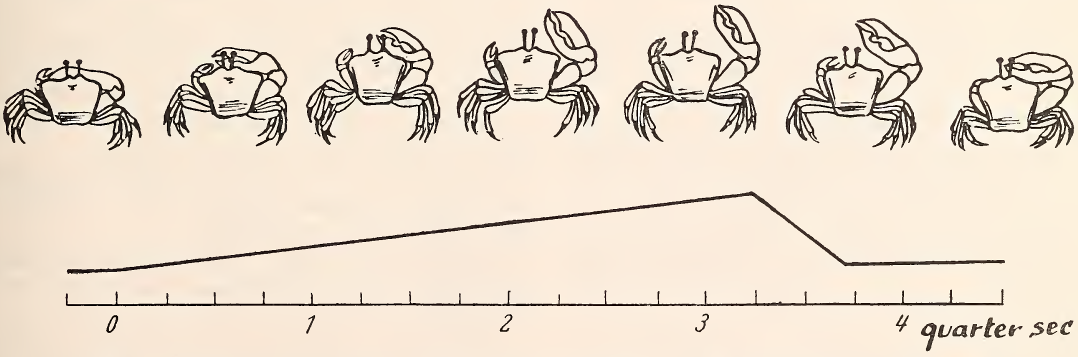

Fig. 4. Waving in *Uca vocans*, dorsal view. Time scale: 1/16 second (from Altevogt, 1955).

and complexity in the waving (and vibratory) signals which may be encountered in the field (For problems of "brachyurization" see also Stevcic 1971). A glimpse of this wealth may be gained from the films listed below which are on loan or for sale by the Institut fur den Wissenschaftlichen Film, Nonnenstieg 72, D-3400 Gottingen, Federal Republic of Germany.

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COMPETITION AND CO-EXISTENCE IN GRIFFON VULTURES: *GYPS BENGALENSIS, G. INDICUS* AND *G. FULVUS* IN GIR FOREST

Robert B. Grubh[1]

INTRODUCTION

If two (or more) different species populations require a common resource that is potentially limited and actually becomes so, they are said to be in competition for it (Gause 1934). When such a situation arises one of the species would eliminate all others directly or through competitive exclusion resulting in ecological isolation. Therefore congeneric species are known to be isolated from each other by range, habitat or feeding habits (Lack 1971). A world review of birds with reference to co-existence of congeneric species by Lack (1971) shows only one exception where two species (*Calidris melanotos* & *C. alpinus*) with identical feeding habits share the same range and habitat for a short period, of 10 to 12 weeks, but that is attributed to temporary supply of superabundant food. Subsequent workers (Vijayan 1975 on 2 species of bulbuls—Pycnonotidae, and Houston 1975 on 6 species of East African vultures) too have added fresh data to strengthen the theory of ecological isolation originally put forward by Gause and further developed by others as shown above.

However, while the theory by itself is logical and on firm grounds, its definition needs to be made more comprehensive in order to explain additional factors hitherto not considered. For instance Kruuk (1967) who observed six species of vultures (Aegypiinae) feeding at carcasses in the Serengeti National Park found that although they all eat off the same carcass, they feed upon different items in the carcass and their feeding techniques also differ. Accordingly he separated the six species into 3 different categories of feeders, 2 species in each category. But he did not go further to explain how the two species in each category sorted themselves out. We get more information on these birds from Houston (1975) who treats individual species in each pair separately and demonstrates how these species have distinctly different feeding habits in spite of the superficial resemblance. However, with the griffon vultures (*Gyps africanus* and *Gyps rupellii*) he found them to have identical feeding habits wherever they occurred together. He justifies their being found together in the Serengeti by the fact that it is only an overlapping area of distribution. Otherwise the large body size of the *rupelli* confines its distribution to hilly terrain while the smaller *africanus,* not so dependent on gliding flight, can feed with equal ease in the plains. Yet this 'overlapping' area is big enough to hold a large and fairly stable population of feeding griffons comprising these two species. Considering the size of the area and the population of griffons involved it would be more reasonable to try and explain how these two species manage to co-exist in the Serengeti rather than put it away as an 'overlapping' area.

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The scope of this paper is to discuss the factors that evidently control a very similar situation in the Gir Forest (Western India) in which three species of griffons are involved: the Indian whitebacked *Gyps bengalensis*, the longbilled *G. indicus*, and the fulvous griffon *G. fulvus*.

OBSERVATIONAL METHODS

The observations included a study of the status and distribution of vultures in the Gir, their population and the feeding habits. Observational methods consisted mostly of observation of the vultures in the wild with unaided eyes or using field binoculars or a portable hide. Captive birds were observed to a limited extent. For details of the methods, see Grubh (1974). The entire study lasted for about 23 months, from September, 1970 to July, 1972.

STUDY AREA AND STATUS OF THE GRIFFONS

The Gir Forest is a hilly terrain of *c.* 1265 km.^{2} area (in 1971-72) having mixed dry teak and savannah, deciduous forest. For more details of the study area, see Grubh, 1978. The Gir accommodates approximately 440 griffon vultures (*Gyps* spp.) at a time in the dry season, from November to May, and 350 griffons from June to October in the wet season. The species composition of the whitebacked, longbilled and fulvous during the dry season is 85%, 8% & 7%, respectively. Indistinguishable feeding habits and uniform distribution within the Gir enable these species to share the same habitats for feeding. The fulvous griffon being a migrant, stays in the Gir only for a little more than 6 months, and hence the wet season finds only the whitebacked and longbilled, their population at that time being about 90% and 10% respectively. (Grubh 1974). We will take that period, when all the 3 species of griffons occur together, for most of the discussion below.

RESULTS AND DISCUSSION

The investigation was carried out with reference to A. the extent of competition among the species, B. interspecific dominance and C. the different factors that enable the species to live together.

A. **Extent of competition:**

Among the different areas of probable competition, the important ones here are food supply, nesting sites, and roosting sites.

1. *Food supply*: On an average only about 8.3 carcasses were available per day during the season and the quantity of meat available from these carcasses, not many of which were intact, was probably just sufficient for the approximately 440 griffon vultures found here (Grubh 1974). With this limited food supply it is obvious that the vultures have to compete for food.
2. *Nesting sites*: None of the 3 griffons nest within the Gir. The fulvous is purely a migrant from outside the state of Gujarat. The longbilled and the whitebacked nest in the neighbourhood of the Gir more or less side by side, but with a difference: the whitebacked nest in trees and the longbilled on cliffs, and hence both are isolated from any possible competition for nesting sites.
3. *Roosts*: Trees and cliffs were used for roosting. While all the three species of griffons roosted on trees, the longbilled and, to a greater extent, fulvous griffons also roosted on cliff faces. But there are only

two widely separated cliffs (Charakio and Nandivilla) within the Gir and these were occupied mostly by the fulvous griffons. Whereas the common roosting trees namely *Sterculia urens, Boswellia serrata & Ficus* spp. were in abundance and hence necessitated no competition, the roosting cliffs, being limited within the Gir, could be a factor causing a certain amount of competition among these two species. However, the fact that there were very few longbills on these two cliffs, even when the fulvous griffons had migrated out, suggests that the fulvous and the longbilled did not actively compete for roosts within the Gir.

B. **Interspecific dominance:**

When assembled at carcasses, the griffons exhibited varying degrees of dominance according to their body size: the largest bird (fulvous) being the most dominant and the smallest (whitebacked) the least.

TABLE 1

INTERSPECIFIC DOMINANCE AMONG GRIFFONS IN THE GIR (N. 74).

Opponents	Total attempted assaults	Percentage of attempts won (In most cases the winners had also initiated the assault)
F × L	15	F 67% L 33%
F × W	7	F 86% W 14%
L × W	52	L 62% W 36%

F: Fulvous; L: Longbilled; W: Whitebacked

C. **Factors enabling coexistence:**

1. *Extraneous factors limiting the population of the larger species and effecting the present species composition*:

Since competition among species is evident only at feed it would be expected that the species composition should be directly proportionate to the level of dominance among the species at least until the most dominant species has successfully eliminated the others from the area. Yet the whitebacked form 85% of the griffon population, the longbilled 8% and the fulvous 7%. This situation needs to be explained. We will first take the case of the longbilled:

The longbilled and the whitebacked, being resident species, breed in the outskirts of the Gir, but prefer different nesting habitats. The whitebacked nests mostly in coconut trees *Cocos nucifera,* Tamerind *Tamarindus indicus,* and trees of the genus *Ficus,* in the plains, around the Gir. The longbilled on the other hand was noticed to be nesting only in the cliffs of the Girnar in the neighbourhood of the Gir. While nesting trees are available in great abundance, nesting cliffs are limited. Although it is not known why only some of these cliffs are used and whether the longbilled is exploiting the optimum number of potential nesting sites, the fact that these cliffs are so limited in the neighbourhood shows that the availability of nesting sites can be a limiting factor for this species.

The population of the fulvous griffon, another cliff nester too may be controlled by this factor, but being a migrant from outside the state, whose status has not been fully understood yet, we cannot explain why they come to Gir in such small numbers. That the scarcity of suitable nesting sites could affect the numerical abundance of a species is also shown by Kruuk (1967) for Ruppell's griffon in the Serengeti.

Thus, we find that the longbilled and the fulvous griffons have not increased in number within the Gir in spite of their being more dominant species. Consequently the whitebacked vulture forms the major bulk of the griffons here, and its number is evidently controlled only by food supply and interspecific competition. The food supply being limited, the number of whitebacked foraging within the Gir would be decided largely by the number of fulvous and longbilled griffons that occur inside the Gir at any one time. Since the proportion of meat consumed by individual fulvous, longbilled and whitebacked is approximately of the ratio of 9:7:6 (based on captive birds from the Gir) the actual number of whitebacked that might be displaced by the other two species can be determined by considering individuals of the different species with reference to their feeding capacity.

The longbilled and the fulvous perhaps do not influence each others number at the feeding grounds as their present numbers are much too small due to the extraneous factors mentioned earlier.

2. *Intraspecific behavioural interaction at feed*: Since the whitebacked is the least dominant species it would be of interest to know how the individuals obtain their food when they are at a carcass along with the other two species. When compared with the whitebacked, the fulvous and the longbilled griffons spend a considerable amount of time quarrelling with their own kind at feeding sites, over food.

While interspecific fights (being between unequal opponents) do not usually last for more than a second, fights between individuals of the some species often last for more than five seconds with a great deal of screeching and other agonistic displays. Each bout of such a fight temporarily debars the fighting birds from feeding. These moments are effectively exploited by the weaker species in obtaining food. Here we find intraspecific behavioural interaction to be a factor contributing towards the co-existence of these species.

In addition to this, the weakest of the three —the whitebacked— has another advantage i.e. its numbers. Its very number and determination to consume food do at times hold back the more dominant species which just stand around and watch them feeding, though not for long.

CONCLUSION

The above discussion indirectly points out that where there is competition for a common resource, one of the competing species may eliminate all others directly or through competitive exclusion only when all the competing species have equal chance to obtain all the biological requirements although there may not be any interspecific competition for these items.

TABLE 2

FREQUENCY OF FIGHTS WITHIN SPECIES

Species	Birds (No.)	Total fights	Obs. period (Minutes)	Interval between fights per pair
Whitebacked	314	61	32.6	84 minutes
Longbilled	128	116	37.3	21 minutes
Fulvous	12	6	47.0	47 minutes

Also, it is found that the extent of advantage gained by a species by its dominance over others can be offset by its intraspecific behaviour. To be short, coexistence among congeneric species is possible even when the common resource is limited under certain situations.

ACKNOWLEDGEMENTS

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DISTRIBUTION AND STATUS OF THE NILGIRI TAHR (*HEMITRAGUS HYLOCRIUS*) – 1975-78

E. R. C. DAVIDAR[1]

(*With two plates*)

INTRODUCTION

The preferred habitat of the tahr are rocky outcrops set amongst grass hills and cliffs bordering grasslands which are to be found along the crest of the southern half of the Western Ghats.

The tahr is a gregarious animal associating in herds which, ordinarily, number between half a dozen and a dozen. Occasionally several herds join together to make large flocks of one hundred or more. The writer came across two such herds, one of 119 in Eravikulam in the High Range in Kerala and another of 101 on the Nilgiri plateau. In composition adult females outnumber adult males in the ratio of roughly 2:1.

Mature males—saddle backs as well as dark brown males ('Brown bucks')—do not remain with the herds always. They normally live on the periphery of herds, joining and leaving them at will. Mature males often join together to make 'buck' parties and there are also true solitaries.

There is no well defined breeding season and young are dropped throughout the year. But there appears to be a peak birth season, which is the winter. One young at birth appears to be the rule. The womb of an illicitly slain female tahr contained two well developed foetuses establishing beyond doubt that twin births occur. Occasionally, a mother with two young at heel have been observed.

Tahr commence feeding at the break of day and feed until late in the evening. They feed and rest intermittently; the rest intervals becoming longer as the day advances, until they become active again towards the evening.

Nights are spent on the cliffs or as close to them as possible. In undisturbed areas, however, they often bed down in the open away from the cliffs.

Where possible, that is, where the country is extensive, the animals wander over a large area. However, due to the recent inroads made into tahr country, by way of hydro-electric projects, opening up of plantations etc., free movement is not possible over most of the tahr's present range. From the manner in which they wander and the readiness with which herds disperse and reassemble it is evident that herds or, for that matter, individual 'bucks', do not stake territorial rights over chosen territory. "Scrapes" or well worn patches of soil are found scattered about in tahr country. These do not appear to follow any pattern. Curiously in some densely populated areas there are fewer scrapes than in some sparsely populated areas. Their significance and function are yet to be investigated.

The food of the tahr consists chiefly of grasses. It is more a grazer than a browser,

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except where they have adapted themselves to comparatively low elevation habitats where much of the food, of necessity, comes from browsing. In this respect the tahr resemble sheep more than goats. The tahr's water requirements appear to be minimal. The tahr do not appear to keep regular drinking hours like other wild ungulates. It is rarely that one meets them near water.

Aggressive behaviour consists of mild contacts, mostly between subadults and consist of light clashes of horns, side butts, shoulder pushes and so on. Such contacts are infrequent. It is rare to see a full blooded combat between two adult males.

The sense of smell in tahr is highly developed. Their sight is keen; better than in many herbivores. During a good part of the year tahr country is shrouded in a thick blanket of mist, when sight is not of much use. The animal must therefore have to rely on its sense of smell and direction to survive in such treacherous country.

The alarm call of the tahr is a sneezy whistle. The animal also communicates in other ways, by foot stamping etc. On rare occasions it has been heard to bleat.

Mortality:

Diseases: It is rare to come across a sick tahr or the remains of one which had perished due to natural causes. Yet the rate of mortality among this potentially fast breeding animal must be high as otherwise there would be much more tahr than there are at present, particularly in areas where the animal enjoys a certain amount of protection from predation, human and otherwise. A saddle back which was shot dead had a growth on its liver. An adult female was observed to have a large growth on its rump. Some tahr in Rajamally were in poor condition. Otherwise nothing unusual was noticed.

Predation:

Predation by animal predators is not a serious threat to the tahr. Leopards pose the most serious threat. In some areas, such as the Nilgiris, leopards have adapted themselves to tahr country and have become expert at tahr stalking and take a regular toll. Wild dogs and tiger manage to secure a kill occasionally.

Poaching:

The commonest method of poaching is by hunting them with the gun. Another method is to lay snares across well known tahr tracks, especially those passing through woods where snares could be properly anchored. Tahr are hunted with dogs in suitable country. Tribals who do not possess arms brought about their destruction by leaving oil stained plantain (banana) leaves along tahr trails in precipitious country.

Tahr meat is believed to possess medicinal properties for the reason that the animal is believed to eat what is known as 'silajit', a jelly like substance oozing out of rock crevices. Some 'doctors' practicing Indian medicine are reported to use tahr flesh in their preparations.

On the credit side there are conditions that favour the animal. Weather is its principal ally. During the monsoons it is impossible to operate in tahr country. For several months in the year, tahr country is blanketed in mist —ground mist rising from below and low clouds from above. Winters are very cold at higher elevations. Thus the animals get respite from hunting for about half the year. Yet another circumstance in favour of the tahr is the weapons in use against it for poaching, which are muzzle loaders and ancient shot guns, have limited range. Besides, tahr hunting is not a game the jeep hunter, who is most destructive, can indulge in.

Tahr is one of the hardiest animals in existence. Extremes of climate obtain in their habitat. In the higher ranges of the Western Ghats, winter is very severe, the thermometer dropping to below 0°C. The summer sun in tahr country is piercing because of the thinner atmosphere obtaining in mountain country. The south-west monsoon accompanied by high winds lash the hills for two to three months followed by the north-east monsoon. Human beings have been known to succumb to exposure overnight during the rainy season. In summer horse flies breed in pestilance proportions in open grasslands and attack tahr and other creatures without mercy. In lower elevation habitats on the eastern slopes of the western ghats, the hills get burning hot in summer from direct heat from the sun and radiated heat from the rocks. It is therefore surprising that this hardy animal which is able to survive all these hazards should find itself in the list of endangered species.

It was with a view to ascertain the present status of the Nilgiri tahr that the survey was undertaken.

Distribution:

At one time the Nilgiri tahr is believed to have ranged over the greater part of the Western Ghats. As late as 1954 tahr were found in the Agumbe ghat—in Karnataka as confirmed by Mr. G. J. Rajasingh, conservator of forests, Tamil Nadu, who saw a small herd there in the course of a boundary survey. Extensive enquiries reveal that there are no tahr in the Karnataka State today.

The tahr's present range is restricted to the states of Tamil Nadu and Kerala. Nilgiri hills is its present northern limit and Ashambu hills the southern limit — 11°30′ N to 8°20′ N. In between tahr are mainly found in a few isolated localities along the crest of the ranges forming the Western ghats at elevations ranging between 1300 m to 2600 m. There are however, a few comparatively low hills where the animal is to be found.

The tahr's partiality to open terrain, the unrestricted view that can be had over long distances in tahr country at the right time of the year and the animals' habit of looking for danger from below and seldom looking up combined to make a count and that too with a certain degree of accuracy, possible.

THE SURVEY

Methods: The sight count method was employed. Ten power binoculars and spotter scopes were used. Tahr habitats were divided into sections for the purpose of the survey and each section was covered systematically.

The following classification was adopted—

Saddle back (old males with saddle marks)—abbreviated—S.B.

Brown back (dark brown male)—abbreviated—B.B.

Light brown male (adult males other than S.B. and B.B.)—L.B.M.

Adult Females—A.F.

Yearling (about 1 year to 2 years)

Young (up to 12 months old)

Classification of L.B.M. and A.F. separately was not attempted as the animals in this group are similar in appearance. Such classification, although possible, would have slowed down the work considerably. Of course, some overlapping is not ruled out.

Earlier surveys of the writer and others are included to make the report complete.

Extensive enquiries preceded, and followed the survey to ensure that every single tahr habitat was covered. Many of the habitats were visited more than once and the survey is a continuing process.

TAHR HABITATS AND POPULATION ESTIMATES

THE NILGIRIS

The Nilgiris or Nilagiri Hills rise abruptly to a height of nearly 2000 meters where they level off into a large plateau about 30 Km. long and 40 Km. broad. The plateau is dotted with peaks and rocky outcrops especially along its rim. Before habitations, cultivation, plantations and man made forests gradually replaced them, the plateau was mostly grassland with evergreen woods, locally known as sholas clothing the valleys and less exposed sections of the slopes. Except where the passes lead into the hills the sides of the hills are fairly steep. This is more pronounced along the entire length of the western face which is an unbroken line of cliffs, in appearance, not unlike the walls of a fortress.

The Nilgiri tahr, locally called the 'Ibex' by sportsmen ranged over most of the plateau until the early part of last century when the Nilgiris began to be "colonized" by Europeans. Some small herds got isolated on some of the cliffs on the North, South and eastern sides of the plateau and lived a precarious existence there. One by one these populations have disappeared, some as recently as ten to fifteen years ago.

The tahr have retreated to the west where they now inhabit a narrow strip of grassland bordering the cliffs about 40 Km. in length and 2 to 5 Km. broad on the average, except on the south-west corner of this country where it widens out—an area of 120 sq. Km. in extent or thereabouts.

CENSUS

Section 1—Mukerti

Locality	S.B.	B.B.	L.B.M.	Yearling	Young	Total
Nilgiri Peak/Terrace		Nil				Nil
Mukerti Slopes	1	1	7	3	4	16
Chinna Mukerti	—	1	5	3	1	10
Chinna Lower slopes	—	1	8	3	4	16
Be Betta	1	—	—	—	—	1
	—	—	2	—	—	2
	2	3	22	9	9	45

(An all male group of 4 saddlebacks was seen a week after the count).

Section 2 — Western Catchment

Locality	S.B.	B.B.	L.B.M.	Yearling	Young	Total
King Dhar	1	2	15	3	5	26
Between W.C. Dams 1 & 2	—	1	2	2	1	6
Igandi	1	1	7	1	—	10
	2	4	24	6	6	42

Section 3 — Nadgani

Locality	S.B.	B.B.	L.B.M.	Yearling	Young	Total
Nadgani	1	3	43	6	9	62
”	—	2	25	2	4	33
”	—	1	5	—	—	6
Varatuparai	1	—	—	—	—	1
”	3	—	—	—	—	3
”	1	—	1	—	—	2
”	—	2	14	5	7	28
”	—	2	11	4	3	20
”	—	—	2	—	2	4
Ridge beyond Varatuparai	1	1	5	2	2	11
Sausage hill	—	—	1	1	—	2
Nadgani cliffs	—	2	8	1	2	13
Simon hut	1	2	15	2	2	22
	8	15	130	23	31	207

When first seen the herd consisted of 101 animals, which later split and the composition kept changing.

Section 4 — Bangitappal

Locality	S.B.	B.B.	L.B.M.	Yearling	Young	Total
Billithadahala waterfall	3	2	13	2	2	22
Cruz hill	—	—	4	—	2	6
Bangi ridge	—	—	4	—	2	6
Bangi slope	—	1	5	—	—	6
	3	3	26	2	6	40
Grand Total	15	25	202	40	52	334

The total number seen was 334. To make doubly sure that there was no duplication, two small herds of 15 and 11 seen in the proximity of the large herd of 101 after its break up was not included in the count. In spite of favourable conditions, it is not improbable that a hundred or more tahr remained out of sight and unenumerated. The total population is estimated at around 450—1975.

SILENT VALLEY

The Silent Valley (11°10′N and 76°25′E) borders the Nilgiris on the south-west. But it is approached via Coimbatore, Anaikatti, Agali and Mukkali or via Palghat, Mannarghat and Mukkali. The valley complex spreads over an area of 16,000 hectares and the valley proper, over 8000 hectares. Tropical wet evergreen forest (or rain forest) covers most of the valley. At the entrance to the valley from the Mukkali side, on either side of the road into the valley, there are some rocky ridges set among grasslands and again as the valley sweeps upwards towards the Nilgiris, the forests yield place to grasslands and rocky escarpments. These hills on the fringes are typical Nilgiri tahr country.

At the head of the valley stands Ankinda malai (2383 m above M.S.L.). This peak and the high hills on either side of it form the northern boundary of Silent Valley. This ‘ridge’ is mostly grassland and is a continuation of the tahr country in the Nilgiris. This part of the Silent Valley is best approached from the Nilgiris side via Ooty, Avalanche, Upper Bhavani and Bangitappal.

Population Estimate

Tahr move freely between Ankinda malai 'ridge' and the grasslands on the Nilgiri Plateau and therefore it is not possible to determine the resident population in the Ankinda malai area. For the purposes of this report the silent valley population may be estimated at around 30.

SIRUVANI HILLS

The Muttukulam hills are better known as Siruvani hills after the Siruvani river which springs from these hills and supplies drinking water to Coimbatore town which is 37 kms away from the foot of the hills. This range is immediately to the South of the Nilgiri hills and North of the Palghat gap (10°55′ N and 76°45′ E) and is one of the smallest hill ranges in the Western Ghats chain. A motorable road winds its way into the hills and at about 9 km from the bottom passes over a saddle (which divides the Tamil Nadu and Kerala States) and descends a short way into a small basin which is 900 m above MSL.

The peaks — Vellingiri Malai, Kunjara Malai, Peria Kunjara Malai, Ayyappan Mudi and others rise sharply from the basin reaching heights between 1500 and 2000 m. Smaller grass covered hills are also found in this basin.

On 22.4.76 twenty tahr were seen near the top of Kunjara Malai (1965 m.). They could not be classified because of poor light conditions. A nearer approach was also not possible as a cliff (which only tahr and Mudigar tribals manage to negotiate) stood in the way. Two days earlier Nanjan a Mudigar guide from Muttukulam, had seen the same herd in that area.

The grasslands on the Kunjara Malai ridge are few and are placed between long stretches of shola forests and the most extensive among them is less than 1 sq. km. in extent. These grasslands are deeply eroded, and the signs indicate that this must be due to over grazing by tahr and sambar over the years. The grass is also coarse, patchy and uninviting and in capable of supporting a large tahr population.

On the other side of the ridge some 10 km away is Elival Malai. Although extensive sholas have to be negotiated it is believed that tahr migrate between the two hills occasionally.

Chaotic conditions prevail in the basin at the moment. Men and machines by the hundred are engaged in building a large dam to replace the old one, under a Tamil Nadu-Kerala water sharing agreement. A road is being built to provide direct access to places in Kerala. It will be years before conditions return to normal, if ever.

Estimated population: 20—1976.

ELIVAL MALA

Elival mala (which means rat's tail mountain), is in Kerala and lies to the North and West of the Palghat gap and South of Muttikulam (Siruvani) hills —(10°55′ N and 76°35′ E). Elival falls within the Chennat Nair Reserve of the Olavakkode Range of the Palghat forest division. Olavakkode is the Range and Divisional headquarters. The mountain range dominates the northern horizon of Palghat and Olavakkode towns. Elival is composed of about a dozen spurs and of these the two dominant, namely, Palamala (2080 m above MSL) and Karimala (2180 m above MSL) constitute the Nilgiri tahr habitat.

The Palamala ridge is short compared to Karimala which is about 10 km long. Although the two ridges are connected at one point they are, as far as tahr are concerned, quite independent, as they are divided by a deep thickly forested valley and the respective cliffs stand isolated in a sea of rain forest. There is no path to the Karimala cliffs from Palamala and the route to Karimala cliffs is from below.

Much of the crest of Karimala is clothed in dense forest and at only two points, namely, the Karimala peak and Kondamala the grasslands are topped by cliffs. It is here that the tahr is usually found. The Palamala grass hill or grass 'mottai', as it is called, along with its side spurs is 3 to 4 km long. The cliffs are a further 3/4 hour stiff climb from the 'forest bungalow flat'. The grazing grounds at Palamala are quite extensive and are intersected by cliffs. The grass is mostly of the *Themeda triandra* Forsk. variety and is coarse.

On the evening of 15-1-77 three adult tahr were seen on the Palamala grass hill and a herd of over twenty on the Karimala cliff, across the valley.

On 16-1-77 the Karimala ridge and slopes were searched with binoculars from a commanding position on the Palamala grass hill and two men combed the Palamala cliffs and ridges for tahr.

The same herd was located on the Karimala cliff the previous evening. There were more animals in the herd this time. There were twentyfive tahr on the slope facing Palamala and about five beyond the ridge, whose outlines could be made out on the skyline. There were over thirty tahr in this herd including three or four young ones. A more accurate estimate was not possible at that distance.

Two herds of five and ten, including a fine 'brown buck' (dark brown male), well away from the three seen the previous evening were seen at Palamala. There were fresh tahr droppings all over Palamala.

At the time of the visit the days were very bright and warm and the grass was coarse, dry and uninviting. Had conditions been more favourable it might have been possible to see more tahr movement. The tahr country is extensive and is capable of holding and, possibly it does hold, more than the forty-eight that were counted.

Estimated population: 60+—1976.

NELLIAMPATHI HILLS

The Nelliampathi hills in Palghat district in Kerala are the starting point of the Western Ghats below the Palghat gap as the 40 Km wide breach in the Western Ghats mountain chain on either side of Palghat town is called. After rising to a height of about 700 m above M.S.L. the Nilliampathies level off into wide undulating valleys where coffee and cardamom plantations and tea at higher levels are situated. The slopes on the East are clothed in deciduous jungle, replaced by moist mixed deciduous jungle in the valleys. Towards the West the jungle is semi evergreen. Higher up there is a plateau the elevation of which is around 1250 m above M.S.L., composed of grasslands interspersed with evergreen sholas. Sheer cliffs drop down from the plateau. This country (10°30′ N and 76°40′ E) is the main tahr habitat on the Nelliampathies. The tahr country is reached by road from Palghat via Nemmara, Padagiri and finally the Manalaroo Tea Estate. From Hill top Bungalow, an abandoned estate manager's bungalow, where the road terminates it is only a short stiff climb to the plateau, which is called the Hill top or Peria Aattu Malai (Big Goat Hill).

On 5.iv.76 three tahr (1 brown buck, 1 adult female and 1 yearling) were seen on hill top. Again on 7.iv.76 a large single tahr (probably the same brown buck) was sighted there, silhouetted against the skyline. On 18.iv.76 a fine solitary saddle back was seen on the eastern edge of the plateau (from Chinna aattu malai, right across the valley). Beyond Peria aattu malai there is Kumul malai which is extremely difficult to approach from Hill top because of an intervening chasm. Bokkan my shikari from Nilgiris along with a local guide went part of the way down the cliffs and there they saw eleven tahr including a young one. He was not able to classify the rest.

On 6th and 8th April Cruz Malai and Chinna aattu malai (small goat's hill), approached from the Manalaroo estate office, were visited. On the 6th four adult and a yearling tahr got disturbed and disappeared down the gully and across the valley. Three were seen on the Kumulmalai skyline, making a total of 8 of which one was young. A herd of 7, in all probability the same animals were seen on the Chinna aattu malai skyline from the estate lines on 3.iv.76 by my guide. On the 8th an adult female tahr and a yearling were seen on Chinna aattu malai. There is no doubt that they belonged to the same herd of 7.

Altogether 23 tahr were seen (3, 1, 11, 8). It is unlikely that many more share this habitat. The tahr were wild and behaved as if they were regularly harassed. The reason for this behaviour was not far to seek. Two poaching parties were operating in the area during my visit.

Estimated tahr population—30—1976.

TOPSLIP AND PARAMBIKULAM

Topslip in Tamil Nadu and Parambikulam in Kerala (10°25′ to 30′ N and 77° E) occupy the northern half of the Anamalai Hills. Being contiguous some of the tahr habitats in this sector fall partly in one state and partly in the other. Therefore Topslip and Parambikulam have been dealt with as one composite area for the purposes of this report.

Topslip, (called after the point from which timber was rolled or slipped down the hill from the plateau to the plains, before proper roads were laid) is the focal point of the Anamalai Wildlife Sanctuary.

Pandaravarai:

Pandaravarai is a prominent ridge running North to South and could be seen from the Topslip forest rest houses across the maidan towards the North-

West. The ridge is in three sections, Pandaravarai in the middle which is the highest point (1300 m), Nanduvai (crab's mouth) and Katardi (windblown) on either side. The inter-state boundary cuts through the centre of the peak, leaving only a third of the ridge in Tamil Nadu. The route to the top is through Karian shola a large unspoilt forest of semi evergreen and ever-green complexion. The shola swarms with leeches when wet. The grasslands and cliffs occupy an extent of 6 to 8 Sq. Km. The grass is mostly of the coarse variety interspersed with hill date palms (*Phoenix humilis*). The grazing grounds are cut up and are beginning to erode due to trampling by tahr and gaur over the years.

On 2.5.76 one adult and one yearling tahr were sighted on the sky line at Nanduvai. They were obviously part of a herd. Before a closer approach could be made night fell. On 3.5.76 eight tahr (1 young, 2 yearling and 5 adults) and one on Katardi skyline were observed. The herd seen on Nanduvai the previous evening could not be located as Katardi could not be reached from Pandaravarai because of intervening cliffs (which however, do not deter tahr from crossing over) it could not be visited. On 6.5.76 Ravi my young Kadan tribal guide spotted 13 tahr on Nanduvai (2 young, 3 yearling and 8 adults). Dr. V. S. Vijayan who was making a survey of wildlife of Parambikulam, visited Pandaravarai some two weeks subsequently and reported having seen two herds of nine and six. Ravi reported the presence of a small herd at Katardi and having seen a large gathering of about 30 tahr earlier in the year. My total count was 22 (8+1+13). With the addition of the small herd on Katardi (of which I saw one and three on 1.10.76 on the skyline enroute to Perunkundru) it is possible that there are around 30 tahr on Pandaravarai. Since the counts were conducted on different occasions duplication cannot be ruled out. Young and yearling accounted for over a third of the population sighted, which is a healthy sign. Considering the eroded condition of the grassland and the fact that it is shared with gaur, it is doubtful whether this habitat can support many more tahr.

Kolumbu malai:

Kolumbu malai 1065 m. above M.S.L. is to the East of the Topslip resthouses. It is the starting point of a long line of cliffs which extends all the way to the Aliyar dam to the South. There are no permanent resident tahr on Umayamalai. The cliffs immediately below also appeared bare. But tahr droppings on the hill indicate that a small herd visit the area off and on, probably when disturbed from elsewhere. Ravi my guide and the men who were cultivating tapioca as an inter-crop among the young teak they had undertaken to plant and nurture for the forest department (under the kumari system of cultivation) at the foot of the hill had not seen any tahr on Kolumbu malai.

Perunkundru:

The tallest peak in the area is Perunkundru 1733 m. above M.S.L. in height and conical in shape. Varakaliar 24 Km. on the Topslip — Manamboli-Valparai forest road is the point nearest to the peak.

On 2.10.76 I visited Perunkundru along with forest guard Manuel, a guide and my son Peter after spending the night at the seldom used Varakaliar forest rest house. One herd of 11 tahr (3 brown bucks, 6 adult females and light brown males and 2 yearling) was seen below the summit and another herd of 7 (1 saddle back, 1 brown buck, 3 adult female and 2 yearling) was seen on a lower slope — in all 18. A herd of 15 gaur was grazing on the summit. Dr. Krishnamoorthy the 'elephant doctor' reported having seen over 30 tahr on Perunkundru some 3 years earlier. This area is an ideal tahr habitat, extensive and having water sources and a rich supply of a variety of grasses. During the time of our visit a leopard had been operating there as its fresh pug marks showed. A leopard's dropping which was perhaps 2 or 3 weeks old contained tahr fur. There were no signs of poaching. Horse flies were active at the time of our visit. It is possible that some of the tahr seen by Dr. Krishnamoorthy had been disturbed by the leopard. The other possibility is that they were hiding away in sholas to escape from the torments of horse flies in the open grassland.

In March 1977 Mr. G. J. Rajasingh, Conservator of Forests, accompanied by Dr. Krishnamoorthy and other officials climbed Perunkundru and sighted over 20 tahr. Mr. Muthumanickam a local sportsman who is opening up a coffee plantation in the Tholanar Valley reported having observed a large herd on the Southern face which according to him, took half an hour to cross a particular point. This was two years ago. The population of tahr on Perunkundru and adjoining slopes (Pachai thanni malai) can be estimated at between 40 and 50; possibly more?

Palagakundru (1172 m):

Mr. J. W. Sykes, Manager, Murugalli Estate reports — "Yesterday (30.4.78), after two abortive attempts in January, I finally managed to reach the peak, (which is immediately above Manamboli-Sholayar Power House I and the upper of the Parambikulam Reservoir) with the aid of two Karders cutting the way for me. There have been vague reports of Nilgiri tahr on this small peak — which is surrounded by dense jungle — but none on any of the other neighbouring peaks. Sadly there were no tahr present but the Karders stated that they are still there. The bare rock peak had 25% coverage of shallow soil with grass — at this stage burnt off and only just beginning to show first signs of regrowth. In fact there were more tahr droppings than soil on the top, but old ones. I personally have no doubt that this is in fact, a small and probably totally isolated herd, probably otherwise not recorded." It is possible that the herd had moved inside the jungle as there was no grazing on the peak. There is a theory that tahr migrate over fairly long distances through jungle. This is yet to be confirmed. This is an area where research might prove useful. "On 29-xii-1978 I ascended the peak and saw a herd of 6—1 brown buck, 4 adult females and 1 sub adult, which appeared to be a complete family group, but I cannot positively exclude the presence of other tahr."

Vengoli Malai:

The Vengoli ridge starting at Vellimudi/Umayamalai in Top Slip and passing through the middle of the two sanctuaries and terminating at Vengoli Mudi in Thunakadavu (which is 12 km. by road from Top Slip) form the backbone of the two sanctuaries. Vengoli Malai in Top Slip (1135 m) is a short stiff climb from Anaikundhi. A section of the cliffs could be seen from the forest road from Top Slip to Anaikundhi. But tahr have not been sighted there in recent times. From the quantity and the age of the different sets of droppings at the top it was possible to make out that a small number of tahr paid casual visits to this peak. On 4.5.76 a small herd of, may be, half a dozen animals was sighted on a slope some distance away on the Kerala side. As they were resting in a close group in the shade a more accurate count was not possible.

Vengolimudi which is also known as Chattiparai is in Thunakadavu. The cliffs face the forest settlement at Thunakadavu across the lake. On 5.5.76 a herd of 9 tahr (1 young 2 yearling and 6 adults were spotted from below; two more, (1 yearling and one adult female) were seen at the top; making a total of 11. The grazing at Vengoli malai as well as at Vengoli mudi is limited. But at Pambamalai an off shoot of the ridge the grasslands are more extensive. Dr. Vijayan reported having sighted 15 tahr in one group a fortnight previously. The total tahr population is estimated at between 20 and 25.

The herd on Vengoli mudi because of its proximity to the Thunakadavu settlement did not seem unduly disturbed and did not react to human presence as these animals normally do, by instant flight. For year round observation and study of the tahr and that too without much exertion Vengoli mudi seems a good place.

Karumalai Gopuram:

The twin peaks of Karumalai Gopuram, so called because of their resemblance to black female breasts, tower over Parambikulam. From the earth dam of the Parambikulam reservoir the summit is a stiff 2½ to 3 hour climb through a leach infested forest. Karumalai Gopuram is an ideal tahr habitat, sheer cliffs on one side and undulating grasslands rich in variety 3 to 4 sq. km. in extent on the other three. Water is available near the summit.

On 6.5.76 I saw five tahr (1 saddle back, 1 brown buck, 2 adult females and one young). Their movement was confined to the South-West face of the hill, may be, because a solitary bull gaur, I ran into had taken up residence near the top.

Swaminathan my Kadan tribal guide mentioned that the five we saw was the largest number he had seen there. Dr. Vijayan and Jayaraj, the wildlife guide of the forest department who had visited the area recently, the latter more than once, averred that they had not seen more than two tahr at a time. From the quantity of tahr droppings it is possible to estimate that there could not be more than seven or eight tahr at Karumalai gopuram. In the herd that was sighted as far as composition was concerned, the ratio between the sexes was disproportionate and for this reason the viability of the population at Karumalai gopuram is in doubt. The peaks stand isolated in a sea of forest and it would be interesting to see if tahr migrations occur between Karumalai gopuram and the distant peaks through this extensive forest.

Estimated population: 120—1976-78.

EASTERN SLOPES OF THE ANAMALAI HILLS

On the Eastern slopes of the Anamalai Hills are some rugged, rocky hills where Nilgiri tahr which became isolated on the opening up of the country in the interior have made their home. Their retreat is not a true tahr habitat and the climate, fauna and flora of these slopes are more lowland than montane in character. The fact that tahr has managed not only to survive but thrive there proves its hardiness and ability to adapt itself to what could be considered an unfavourable environment. But it may be mentioned that if the tahr on these slopes made a serious attempt they can get to the high hills on the West through unopened country on the south. But they have not chosen to do so.

On either side of the road to Valparai (10°25′ N and 77° E) there are five scattered tahr populations. Some of these remain isolated by roads, dams and canals of the Parambikulam-Aliyar project, but between others communication is possible. This area falls within the Anamalai Wildlife sanctuary and is administered by the Wildlife Warden at Pollachi.

Aliyar:

The township of Aliyar at the base of the hills is 22 km from Pollachi and is situated below the Aliyar dam.

The rocky hills west of, that is, to the right of the Valparai road as it climbs into the hills is the habitat of the Aliyar tahr. These hills form a ring around the valley drained by a little jungle stream known as the Chinnar, with Pachamalai at the apex, and the Chinnar gorge opening out into the road at the base. The area is known as Villoni and is in the Poonachi forest range.

A brief visit was made on 26.ii.77 but no tahr was sighted. But a party of picknickers reported having seen a herd of about 20 tahr on a rock north of Chinnar the previous week.

On 16.iii.77, Bokkan my shikari from the Nilgiris and I accompanied by Neelan and Gokulan, Malai malasar tribals living in the Aliyar tribal settlement climbed into the hills. 3 tahr (1 female and 2 subadults) which were resting in the shade on a slope of the northern ridge were disturbed at fairly close quarters. Two herds which were partially hidden beyond the opposite ridge's skyline (Peria and Chinnasalla Katti) were seen. On closer approach Bokkan and the local guides counted 14 animals in two herds of 8 and 6 on the Southern ridge.

At noon on 17.iii.77, a herd of 5 tahr was seen on the upper end of the Northern ridge. On 19.iii.77, 13 tahr were seen on Pachamalai. Some of the tahr seen on the northern ridge where met with more than once during the count, and care was taken to see that there was no duplication. Altogether 35 tahr were seen. According to Neelan, who visits the Chinnar Valley frequently in search of edible tubers, there are two herds in the area, one on the road end and the other at the Pachamalai end with about 30 animals in each. Direct heat from the sun in March during the visit was bad enough but the radiated heat from the rocky hills was worse and consequently the animals seldom ventured abroad during the day. Because of this factor and the interspersed trees, viewing was difficult. Neelan's estimate of 60 or so should be close to the mark. Very few young animals were seen. There were no signs of poaching or predation. An occasional leopard or a pack of wild dogs is said to operate in the area.

Chetta Guttu — Ninth Hair Pin Bend Hill:

The row of hills to the south-east and the Aliyar/Attakatti hills "meet", so to say, at the ninth hair pin bend on the Pollachi-Valparai road. According to Neelan this hill was a favoured haunt of tahr before men started quarrying stone on the top of the hill near Attakatti for the P. A. Project. The quarry has now been abandoned.

A saddle back was reported to have taken up residence on the slope above the ninth hair pin bend about a year ago and was seen off and on by motorists passing along the road. On the evening of the 16th proceeding to Attakatti, I saw the saddle back, a very old animal standing on the hair pin bend's parapet wall itself! It was accompanied by a younger saddle back. On 29.iii.77 a small herd of 5 tahr — the saddle backs not among them — was seen by some planters and Mr. B. Devarajulu the Game Warden. On 7.iv.77 seven tahr were seen in the same area by Mr. Kumaran, a planter. They could have come from either direction. This is a very busy place, vehicles passing up and down at short intervals right through the day and night. The tahr did not appear to be unduly disturbed by the traffic. It is hoped that they take up permanent residence there.

Attakatti Cliffs:

Attakatti is 35 Km from Pollachi on the road to Valparai and is 1000 metres in elevation. A kilometer or so behind the Attakatti township and to the right of the road as one travels up the ghat is the tahr habitat. It is a 3 to 4 Km stretch of cliffs and grass covered slopes. It overlooks Villoni and Aliyar. At the south western end is the Varaiattu Mottai peak which is about two hundred metres above the Attakatti plateau. This peak could be approached through the Waverly Estate also. A brief visit was made to the peak on 27.ii.77, but as tree felling was in progress in the valley below, no animals were sighted due to disturbed conditions.

On 17.iii.77 the cliffs were visited. One female tahr accompanied by a young one which was passing on into the sub-adult stage; a group of four composed of adult females and light brown males and a small herd of 6 (1 young, 1 sub adult and 4 LBM and AF). A large male, which could have been a part of a herd, was seen on the Varaiattu Motti skyline. In all 13 tahr were counted. It is reported that because of easy access the Attakatti tahr population was subjected to much harassment by "sportsmen" residing in the towns in the plains below until stricter control was enforced since 1973, when the range was declared part of the Anamalai Wild Life Sanctuary. Between Chetta guttu and the Attakatti cliffs there is an estimated population of 20 to 25 tahr.

Thadaganachi Malai:

The Thadaganchi malai is an off shoot of the Anamalais and is situated west of the Aliyar dam. A dirt road leads to the foot of this range from the junction of the old Valparai road and the new road. The Thadaganachi peak (1693 metres above M.S.L.) is the highest peak in the area. The country around the twin peaks in this range is an ideal tahr habitat. On 18.iii.77, while Bokkan and Neelan circled this range from the west and north, Gokulam and I approached it from the south. Bokkan and party saw one herd of sixteen which included a young and a dark brown male. We could catch a glimpse of only one tahr as it disappeared into a hill bamboo brake. Fresh droppings on the slope indicated the presence of a herd. This range is connected to the main range by a series of low hills. There is a lot of cattle grazing in the area. Poaching is reported.

Navamalai:

Navamalai means nine hills. There are nine hills placed around the top of Aliyar reservoirs on either side of the Navamalai power house. Puragundu (pigeon rock), the hill on the north western end is the main tahr habitat. Butha gundu adjacent to it also holds tahr. Navamalai is 33 Km from Pollachi — 6 Km off the Pollachi — Valparai road. The road throughout is good.

On 6.xii.77, altogether 23 tahr were seen on Puragundu and 4 on Buthagundu. On 7.xii.77 two groups of 6 and 17 were seen. On 18.xii.77 21 tahr were seen in one group on an open rock and classification was possible. 2 saddle backs, 1 dark brown male, 13 adult females and light brown males, 2 subadults and 3 young were in that composite herd. It is estimated that there are altogether 30 tahr at Navamalai. The proportion of young and sub-adults to adults is low. The animals appeared to be in good condition.

Estimated population: 125—1977.

GRASS HILLS IN ANAMALAIS

The Grass Hills is a 65 sq. Km. plateau placed at an elevation of approximately 1800 m above mean sea level in the Anamallai Hills in the Coimbatore District in Tamil Nadu (10°15′ N and 77°5′ E). The approach to Grass Hills is through the Peria Karamalai group of Estates off the Pollachi-Valparai road. The last 10 Km. is a forest road which is invariably out of commission for cars during and after the rains. The Hills take their name from the undulating grass-topped hills reminiscent of the 'Downs' on the Nilgiri plateau; the Grass Hills Downs, however, are not as extensive as the Nilgiri Downs as they are intersected by high ridges. The cliffs are also not sheer and invulnerable as in the Nilgiris. The grass on the grass hills is the coarse (*Agrostis schmidi*) variety. Evergreen sholas clothe the folds and valleys.

The plateau is bounded on the North and northwest by jungle and tea plantations and on the northeast, west and south-west by jungle and on the south and south-east by extensive grass hills of the Anaimudi Sanctuary.

The survey was done over a period of seven days between 3.iv.1971 and 9.iv.1971 (inclusive). Weather conditions were ideal and visibility was excellent. Grass had burnt extensively and fresh young grass was growing in patches and the tahr tended to congregate in such places.

Altogether five herds were seen in the following areas:

1. Kallar Malai — First sighted on 4.iv.1971 on the S.E. slopes — moved on to the northern slopes on 5.iv.1971. Remained there breaking up and regrouping until 9.iv.1971.

Saddle back	0
Brown buck	2
Light brown male & adult female ...	38
Yearling	0
Young	14
	54

2. Chadayandi Malai — First sighted on 4.iv.1971 on this hill. From 5.iv.1971 until 9.iv.1971 this herd was seen on the Kaludai Katti Malai where it had moved.

Saddle back	0
Brown buck	1
Light brown male & adult female ...	11
Yearling	0
Young	4
	16

3. Tanaka Malai — First sighted on 5.iv.1971 on S.E. slopes — later the herd had moved higher up and towards the west.

Saddle back	0
Brown buck	0
Light brown male & Adult female ...	13
Yearling	7
Young	7
	27

4. Tanaka Malai — Western slope towards Koram Parai.

Saddle back	1
Brown buck	0
Light brown male & Adult female ...	4
Yearling	1
Young	0
	6

Apparently these two heards had come together and on 8.iv.1971 — altogether 35 animals were seen against the skyline late in the evening. The two new entrants could not be classified.

5. Usi Malai.

Saddle back	0
Brown buck	1
Light brown male & Adult female ...	16
Yearling	2
Young	11
	30
Not classified	3

Mr. G. J. Rajasingh, Conservator of Forests, Coimbatore circle who visited the Grass Hills in 1976 reported having seen many herds of tahr one of 60-70, others of 25, 16, 12, 8, 4 and 3.

Estimated population: 200—1971/1976.

AMARAVATHI SLOPES

Due South of Udumalpet, which is between Pollachi and Palani on the Coimbatore-Dindigal road, some spurs of the Western Ghats project into the plains. Not far further south this mountain chain makes further and more extensive inroads into the plains in the shape of the Palani Hills. Tucked away between these two projections is the Amravathi-Manjampatti Valley. The Amaravathi township at the foot of the Amaravathi dam is of recent origin and is the focal point of this region. The township is 6 Km off the Udumalpet-Munnar road and is altogether 22 Km from Udumalpet. The country around Amaravathi (10°15′ N and 77°15′ E) is comparatively low and unpromising as a Nilgiri Tahr habitat and it is, therefore, not surprising that few know of the occurrence of tahr there. The reserved forests in this area fall within the Anamalai Wild Life Sanctuary and are administered by the Wild Life Warden stationed at Pollachi.

Jambukal:

This isolated rocky mass, only 919 m in height at the highest point, which is fairly low for a tahr habitat, stands at the entrance to the Amaravathi township. Jambukal has the unique distinction of being the only tahr habitat falling outside a reserved forest. Jambukal is a revenue forest and because of lack of protection every single tree on this hill has been hacked down. And every bit of land suitable for cultivation has been encroached upon and is being cultivated without regard to soil conservation. Mr. Muthuswamy Nadar, an affluent agriculturist and a knowledgeable shikari of Udumalpet reports that 15 to 20 years ago Jambukal had a population of about 50 tahr and that poaching, which took place on an organised scale, and habitat disturbance have virtually wiped out the Jambukal tahr. Two residents of Ilayamuthur at the foot of the hill who acted as guides state that the few tahr that are left, which they estimate at less than half a dozen, are in hiding and are very difficult to come across. They also thought that tahr migrated to Jambukal from the Elumalaiyan Koil spur across the Munnar road and that these migrations have stopped with the coming of electricity and the setting up of well lit and fenced farms in between. Some of the more promising sections of Jambukal were kept under observation on 4.iv.77 and 6.iv.77, but no sightings were made.

Erumai Malai (*Bison Hill*):

This hill stands at the head of the Amaravathi reservoir and could be approached either by walking along the Eastern shore of the Amaravathi reservoir and crossing the Pambar river above Duvanam, the waterfall at the head of the dam or by motoring along the Munnar road up to Chinnar and walking or proceeding by jeep from there.

A more unlikely tahr habitat cannot be imagined. The Manjampatti valley floor is about 300 metres above M.S.L. and Erumai Malai cannot be more than a further 500 to 600 metres at the highest point, about 1000 metres altogether. The Elumalaiyan Koil spur which is a more favourable tahr country is not far from Erumai Malai across the country and the tahr could shift there if they wanted. In these circumstances why they continue to favour Erumai Malai is inexplicable.

In summer Bison Hill could well be described as inhospitable and the heat is intense. Areawise also it is not a large hill, about 12 Sq. Km. in extent; the tahr habitat being a third of this. Mr. Muthuswamy Nadrar who had hunted there before it was made a sanctuary in 1973 called it a "one man beat". For most part it is surrounded by a belt of cliffs from half way up the hill to the top. The soil on the slopes, where it is not rocky, is loose and gravelly and provides poor foot hold. The composition of the flora unlike that in regular tahr habitats could be best described as 'savanna scrub'. However, there is a fair amount of grass of medium height on the two small plateaus on the top of the hill.

Census was taken on 5.iv.77 with the assistance of Bokkan, from the Nilgiris and two local guides, the details of which are given below:—

Saddle-Back male	Dark Brown male	Adults female & light brown male	Sub Adult	Young	Total
—	—	4	2	2	8
—	1	—	—	—	1
1	—	2	1	—	4
—	1	7	1	5	14
—	—	3	1	1	5
—	—	2	—	1	3
—	—	5	2	3	10
1	2	23	7	12	45

Because of the smallness of the area it is possible that some animals were counted more than once. But the local guides were certain that the tahr on Erumai Malai number over one hundred! This seems an exaggeration. This hill is one of the few tahr habitats where it is possible to take a fairly accurate count by organising a drive with a score of beaters. The count also showed that Bison hill is a regular tahr nursery. 25% of the population were young; the highest ratio of young to adult seen in any tahr population.

No water sources were observed on the hill at the time of visit. The Pulayur tribals who live in a cave at the foot of the hill, but across the river had not seen tahr come down to the river to drink. How and from what source do the Bison hill tahr get their water requirements? The tahr is a hardy animal which does not have to drink as often as for instance some deer. But how long can it survive without water? These and other related aspects are proposed to be studied in depth by the writer.

Elumalaiyan Koil Hills:

To the North of and almost paralled to the Udumalpet-Munnar road where it enters the hills is a spur which joins the Anamalai hills on the North and High Range in Kerala, on the West. The upper crest of the spur and the adjoining ranges are typical tahr country. It is reported that the hills around Maraiyur have been cleaned out of tahr by the Muduvans, a hill tribe, some of them being expert and enterprising poachers. This spur, as such, as far as it could be gathered, has no particular name. For easy identification it is called after the temple for the deity Elumalaiyan, which is located there.

The temple is a good one and a half hour walk from the Munnar road and it is placed at the base of a long ridge ranging in elevation from 800 to 1200 metres above M.S.L. The north-eastern end of the ridge is known as Rasi Varai and the south-western end, at Veedankottai (Hunter's fort) and the tahr appear to be partial to these sections of the ridge.

On 6.iv.77 while Bokkan accompanied by the two local guides climbed Veedankottai, I climbed Rasi Varai. It was a stiff climb along overgrown game trails, mostly used by elephants and gaur, especially after the rains. The grasses on the top are the tall varieties more favoured by gaur than tahr. At the time of the visit Rasi Varai was covered with fresh young grass shoots after a fire. Signs of tahr was evident.

Although piles of day old droppings and fresh tracks were everywhere on the summit only 5 tahr were sighted, (2 adult females; an adult female accompanied by a yearling and an abandoned, partially crippled young), (which in spite of the best efforts of my guide and myself could not be captured). Even these few were wild and showed signs of having been disturbed recently. The reason for this was not far to seek.

A party of four men whom we saw on the top when we were half way up the hill, who were probably timber poachers, had camped on the summit the previous night. We also saw a party of two hunters, on a peak behind the ridge, and one of them had a gun. My guide stated that men from the villages below came up each summer, when the agricultural operations had ceased, to cut wood and poach. It was not difficult to make out from the varying size of the fecal pellets that there had been between 30 and 40 tahr on Rasi Varai the previous day.

Bokkan had better luck on Vedan Kottai. He and Gopal, the young Pulayar guide, who lives in a tribal settlement near Elumalaiyan Koil saw 25 tahr in one herd. (2 dark brown males, 15 adult females and light brown males, 8 young and sub adults). According to Gopal there are two large herds of over 30 animals at each end of the ridge at Rasi Varai and Vedan Kottai.

Checking the sporadic poaching that takes place on the spur is a difficult task. Action has to be taken in the villages supplying the poachers. It should not be difficult to identify and keep a watch over them. There were not many signs of predation.

Estimated population: 130—1977.

SWAMIAMALAI KARADU

This Karadu or ridge, an off shoot of the Palani hills, is south of Amaravathi and lies in the Madurai district (10°20′N and 77°25′E). The route to Swamiamalai is via Papampatti or Andipatti West of Palani the famous temple town. It involves a trek of over 20 km. in the plains and a stiff climb of 7 km. H.H. the Raja of Pudukottai who had hunted in the area many years ago reported the presence of tahr on the Karadu. In September 1976 he had Swamiamalai checked by sending two of his experienced shikaris there. They reported sighting 15 to 20 tahr. Some of the neighbouring escarpments look promising. Tahr are reported on Sandumalai.

Estimated Population: 20—1976.

ERAVIKULAM AND RAJAMALLAY

Nilgiri tahr habitats of Eravikulam and Rajamallay are in the High Range in Kerala (10°10′ and 77°5′E). They can be reached by road from the Kerala side as well as from Udumalpet in Tamil Nadu. The last 12 Kms or so to Eravikulam has to be trekked over a bridle path which could also be ridden over on motor cycles in fair weather. Rajamallay is just off the Udumalpet-Munnar road on the way to the Rajamallay tea estate. Dr. George Schaller censused the tahr in these two habitats in October 1969 and his report is extracted below.

"The High Range with its deeply dissected valleys, massive peaks and towering crags is 'surpassingly grand, and incomparably beautiful', in the words of Hamilton (1892), *one of the first visitors to the area in* 1854. *Tea Plantations now cover the valleys, leaving indigenous forests only on the steep slopes, but the cliffs and grassy plateaus above an altitude of* 2000 *m. still provide suitable tahr habitat. The Eravikulam area, also known as Hamilton's Plateau, a private shooting reserve*

owned by the Kanan Devan Hills Produce Co., Ltd. (Now Tata Finlay Ltd.) contains the largest tahr population in the High Range. Protected from poachers, pastoralists, and agriculturists since 1895 by the High Range Game Preservation Association as well as by the cliffs that border the 80 sq. km. plateau on 3 sides, the tahr there have remained relatively undisturbed in recent years. Fire and slash-and-burn cultivation by the Muduvars, who occupied the area sometime after the 14th century (Thurston 1909) are probably responsible for the little forest that is left on the plateau.

A total of 439 tahr were seen. In addition, fresh signs indicated the presence of another herd but I was unable to find it in the clouds that engulfed the hills at the time. The total number of tahr in the reserve was thus about 500".

In December 1973, that is, four years after Dr. Schaller conducted his survey, I spent a few days in Eravikulam and was able to see without much exertion more than 200 tahr, including a herd of 119.

In March 1978 I spent a few days in Rajamallay and saw in all three herds of 20, 31 and 8 and two strays. The permanent population on the Rajamallay cliffs is reported to be between 60 and 70. Some visiting herds are reported to come and go. Among the 61 seen there were 17 young, that is 28% of the population. Even if half the young survived they would have more than made up the loss due to old age, disease, predation and poaching. Assuming that there was only a marginal increase in population over the past 10 years, this would have brought the total population to 600 or more. Moreover, knowledgeable people feel that Dr. Schaller's estimate of 500 was a gross underestimate. A conservative estimate of today's tahr population in Eravikulam and Rajamallay would put it at around 650.

Rajamallay has been a tahr sanctuary for long and well looked after by the company. Eravikulam has been a sanctuary for a few years. Recently both have been accorded the status of a National Park and named after the Anaimudi Peak, the highest peak in South India (2700 m) around which the park has been formed. A wildlife research unit is being set up at Rajamallay.

A tahr with a collar round its neck is among the resident herds advertising the fact that snaring is practiced in that area. The snares ought to be searched out and destroyed.

Estimated population: 700—1969-78.

HIGH RANGE—LESS KNOWN PLATEAUS

Besides Rajamallay and Eravikulam the main tahr habitats in the High Range in Kerala there are some less known areas separated from the main range by roads, jungle and tea plantations which are reputed to hold the tahr (10°5′ to 10′N 77°5′E). Mr. Samar Singh the President of the High Range Game Preservation Association had these areas surveyed in June 1976 with the help of Muduvan game watchers of the Association and his report is given below.

1. *Tertian's plateau*: "Lying above and in between Gundumallay and Chunduvarrai/Kundaly Estates.

   1 Saddle Back
   1 Brown Buck
   7 Adults
   2 Young
   —
   11
   —

   (This total number of 11 has been more or less steady for the last few years.)

2. *Karunkulam*: Lying between and above Arivikad and Yellapatty Estates.

   2 Saddle Backs
   2 Brown Bucks
   9 Adults (L.B.M. & A.F.)
   4 Yearlings and young
   —
   17
   —

   (This total number would appear to have reduced considerably from 60 to 80 some 10 to 15 years ago).

3. *Periavurrai/Kannimally Ridge*:

   4 tahr sighted—probably all does. (This area has not been known to have tahr for quite some time now and I presume these four had moved over from Rajamallay area).

There is no news of tahr sightings in any other area around here".

Estimated population: 30+—1976.

PALANI HILLS

The Palani Hills, named after the famous

Palaniandavar Hill temple at Palani perched atop on one of its foothills, juts out into the plains of Madurai district. They rise gradually to a 1800 metre high plateau, 450 Sq Km in extent, called the upper Palanis, which terminates abruptly in sheer precipices on the south and south-west sides. The well known South Indian hill resort of Kodaikanal or Kodai is on this plateau.

The upper Palani plateau is extremely scenic. The southern face, from Kodai to Vandarav, a distance of 40 Km., is just one unbroken chain of precipices, like the ramparts of an immense fortress. Extensive grass-topped undulating hills, or downs, interspersed with evergreen sholas, roll back northwards from the cliffs edge. From Marian shola to Vandarav, these stretch right across the plateau covering over 100 sq. Km., one of the finest downland expanses anywhere, despite the wattle plantations here and there. The Kodai-Munnar road runs parallel to the cliff line, in some places within a few metres, and nowhere more than a couple of hours' walk from it. Moreover, the entire plateau is dotted with cliffs, as in Adukkam, Perumal Malai, and Poomparai. It is an ideal habitat for the Nilgiri tahr.

Prior to my survey in 1973, no serious attempt seems to have been made to ascertain the tahr's status which would have facilitated a comparative study. However, I was fortunate in having been the guest of H.H. the Raja of Pudukottai who has spent every summer for the last 25 years of more in Kodai, knows every inch of the tahr country, and has shot many saddlebacks there. According to him 25 to 30 years ago there were well over 1000 tahr in the Palanis. He showed me a dozen cliffs within a radius of 20 km of Kodai which, 10 to 20 years ago, held thriving tahr populations, some as recently as five years ago. His men told me that tahr used to move in droves like domestic sheep and goats.

My survey was conducted between April 12 and 20, 1973. Conditions were ideal, except for the usual ground mist which roll up from the plains and obscure the cliffs for a few hours every day. Grass had burned extensively and fresh young grass was sprouting in large patches, an open invitation for a tahr gathering. The burning also helped to set the tahr in bold relief against the mountain side which made spotting easier.

The Raja arranged for two experienced shikaris to assist me, and he himself accompanied us on many of the trips. With a long range telescope and powerful binoculars we covered systematically, section by section, the entire southern cliff line from the Pali varai (cliff) below the golf links to Vandarav, double checking the more promising sections. Our total was 23.

Marian Shola varai
2 Adult females
2 Young
—
4
—

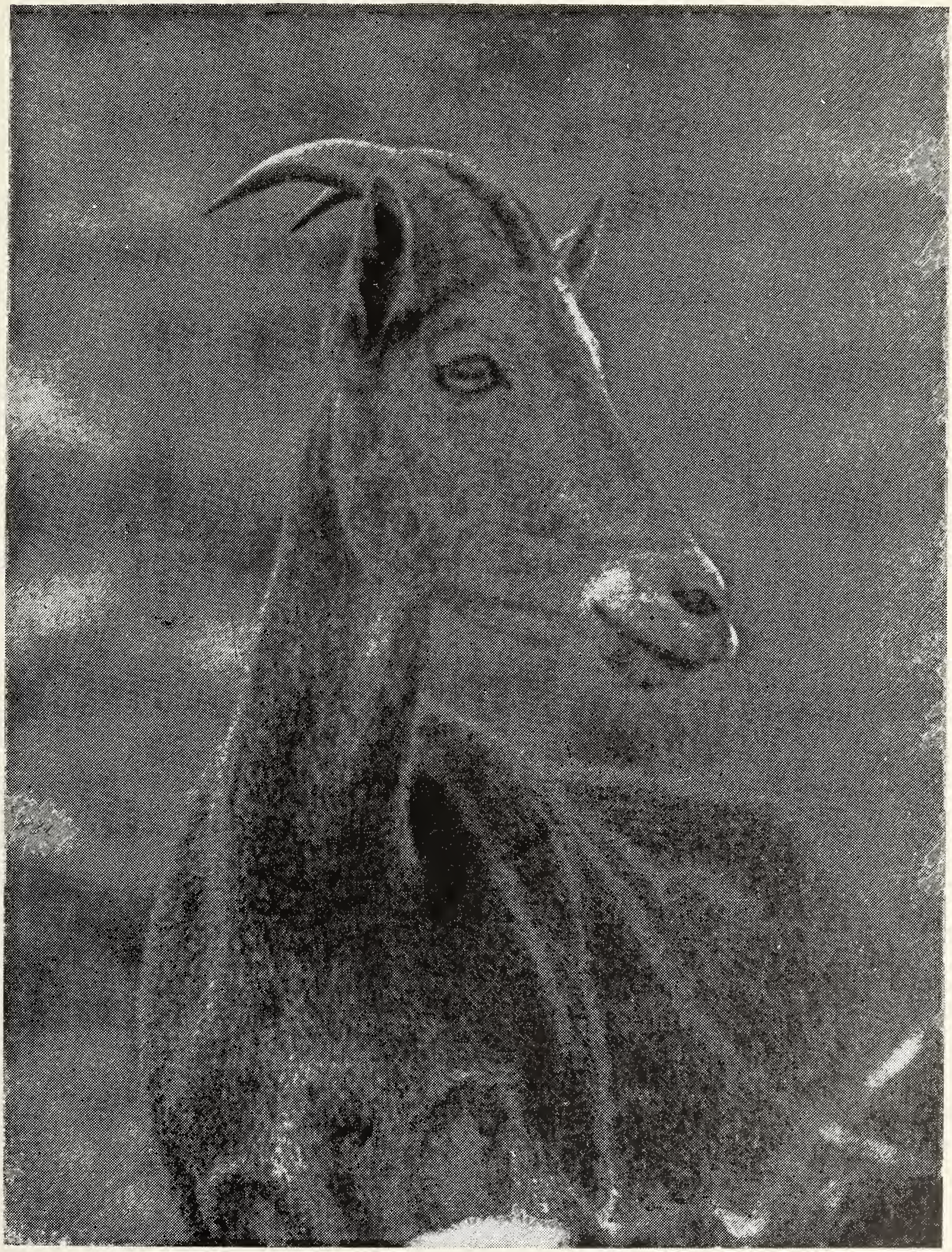
Karian varai
1 Light brown male
1 Adult female
1 Young
—
3
—

Koravan Thotti
1 Saddleback
1 Brown buck
7 Adult females and light brown males
4 Yearling
3 Young
—
16 Total : 23.
—

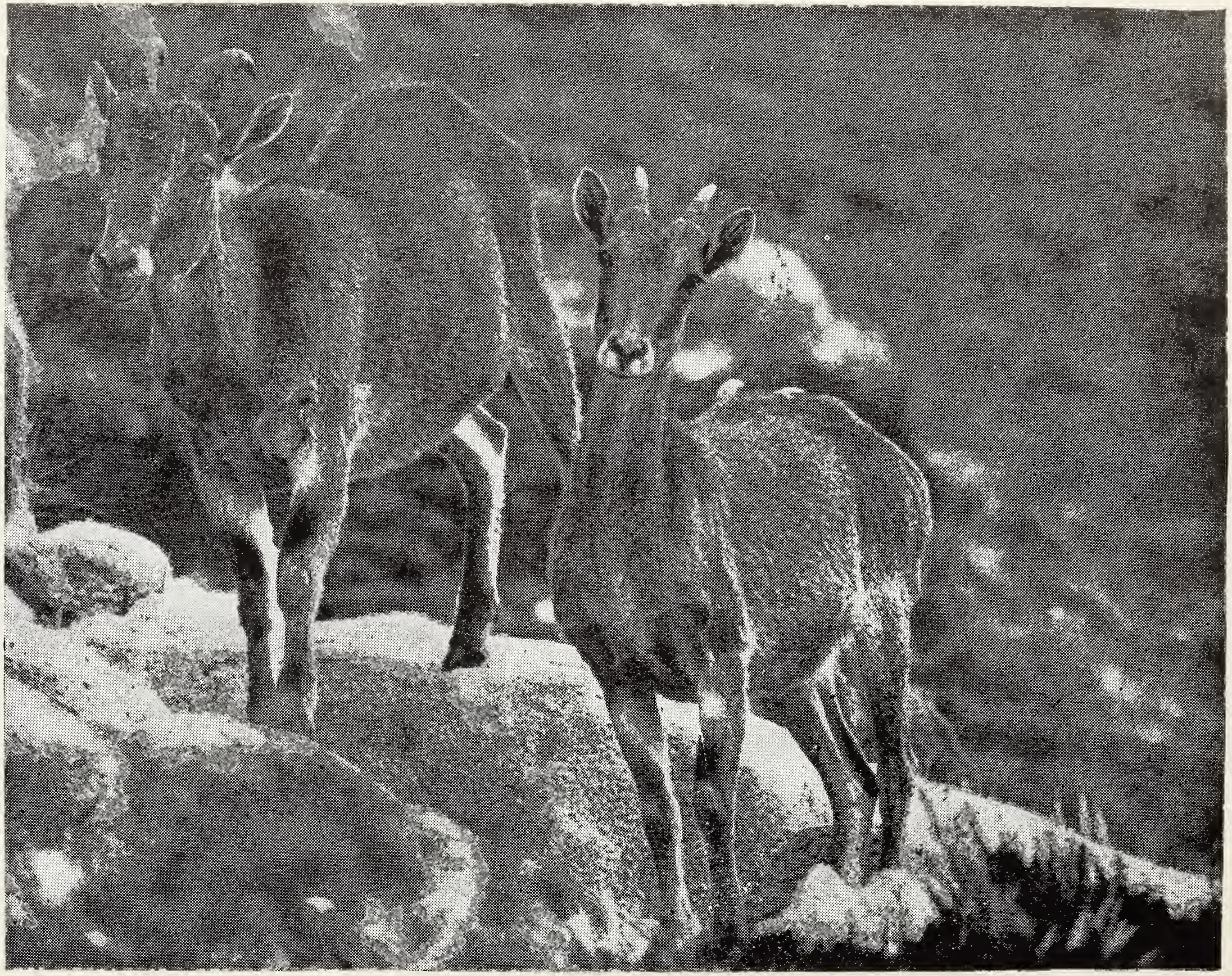
We were unable to visit Kaluguthorai and Vannathi odai cliffs, as the road had been dug up. But a herd of 12, including a saddleback, is reported there. On May 25, 1973, the Raja saw ten tahr in Sooriankanal in two herds (one saddleback, four adult females and two young—one brown-back and two adult females). This brings the total to 45. Even allowing a liberal 35 per cent error margin for animals that we might have missed in the count the total tahr population in upper Palanis is unlikely to exceed 60. A shocking case of wildlife decimation.

Of the 23 animals, seen, six were young (eight out of 33) a healthy 25 per cent growth rate. Given adequate protection and a proper environment—which means restoring the original habitat along the cliff line by keeping it free of cattle and wattle there is no doubt that the Palani Hills tahr will rehabilitate itself.

Estimated population: 60—1973/75.



Portrait of an adult female Nilgiri Tahr.



Subadult and adult females Nilgiri Tahr.

HIGHWAVY MOUNTAINS

The Highwavy Mountains (Megamalai)—9°42′ N and 77°20′ E—are in the Madurai District of Tamil Nadu. The range has no true plateau, the top being cut into steep-sided valleys. The narrow strip of fairly level ground on which the road is laid, which for convenience can be called the "plateau", averages 1600 metres but some of the summits reach over 1800 metres. Until 1931, when a tea company obtained a concession over the mountain from the Gandamanaikanur Zemindar they were covered with thick evergreen sholas. Some of these survive where they have not been replaced with tea.

The tahr inhabit five grass-covered rocky outcrops projecting from the mountain range: Metla Malai, Kudamparai, Plot No. 28, Varayatu Mottai and Attu Mottai (Pathukudisal). Except on Attu Mottai there are no steep precipices, as in the Nilgiris or the Palanis; the cliffs are no more than a few hundred feet high, and are easily accessible from both above and below, and none of the grass lands cover more than a few square kilometres.

The approach from the plateau to all five tahr grounds is through the tea gardens. There is a motorable road to within 200 metres of Varayatu Mottai, but the others involve treks through the jungle, varying from half-an-hour to four hours for Kudamparai, the most distant.

No earlier attempt seems to have been made to census the tahr population on the Highwavys or for that matter the other wildlife there. Even the report of the Bombay Natural History Society's 1917 expedition to the hills, of which Prater was a member, makes no mention of the larger forms of wildlife found on the mountains (JBNHS, Vol. XXXI, p. 545). However, Mr. E. W. G. Hagger, a director of the plantation company who has been familiar with the area since 1955, writes about the tahr (which he calls "Ibex" after the local practice): "In 1956 I saw herds of over 100 on the Metla and Varayatu Mottai. I would guess conservatively that altogether in the early fifties there would have been at least 500 ibex on these hills. The opening up of the Varushanad Valley and the road to Vellamalai had a profound effect on the ibex population".

My count yielded the following figures:

Padicattu Metla — Southern slope

First Herd	
Young	1
Adult female and Light brown male	4
Brown buck	1
	6

Second Herd	
Young	1
Yearling	1
Adult female and Light brown male	5
	7

Mudal Metla

1	Young
3	Adults
4	

Varayatu Mottai (Venniar) 6.12.72

First Herd	
Young	2
Adult female	2
	4

Second Herd	
Young	1
Yearling	3
Adult female and Light brown male	7
Brown buck	1
	12

Attu Mottai (pathukudisal)	
Yearling	2
Adult female	2
	4

Plot No. 28. 7.12.73	
Young	3
Yearling	2
Adult female and Light brown male	4
	9

Kudamparai could not be visited, but Mr. Palaniappan's shikari reports having seen there five tahr there (two adult males, three adult females). A saddleback and four others were seen a week previously at Plot No. 28. Mr. Palaniappan's subsequent counts and recounts yielded the following figures:

Attu Mottai — 2 brown buck, 5 adult females and 2 young: Total — 9.

Padicattu Metla — 2 brown buck, 7 adult females, 5 young, not classified 6: Total—20.

Mudal Metla — 1 saddleback, 8 young, 18 not classified: Total — 27.

Thus the total tahr population can be taken to be 20 + 27 + 9 + 14 + 16 + 5 = 91 or, say 100. The animals were healthy and did not seem unduly disturbed, the ratio of young reveals a healthy growth rate. The rechecks have revealed the remarkable fact that the Highwavys tahr have learned to adapt themselves to their environment by extending their limited preferred habitat of grassy hills among rocky terrain to include surrounding shola forests which tahr normally avoid.

Estimated population: 100—1972.

SRIVILLIPUTTUR AND RAJAPALAYAM HILLS

The Western ghats rises like a rampart behind (west of) the towns of Srivilliputtur and Rajapalayam which are in the Ramnad district in Tamil Nadu. The towns about 15 Km apart are important stops on the Madurai — Trivandrum railway line. They are on the Madurai — Tenkasi highway. Roads lead to the foot hills from the towns and from there bridle paths, which are quite steep in places, take off into the hills.

a) *Mudaliar Oothu* (9°33′ N and 77°35′ E).

Mudaliar Oothu is a perennial spring situated at an altitude of about 1500 metres above MSL in the Srivilliputhur forest Range. About a 100 metres North of the spring is a forest rest house—the Mudaliar Oothu bungalow. Owing to neglect the bungalow is in bad shape and will soon be in ruins. The Mudaliar Oothu is accessible from Pudupatti Village also.

Running behind the bungalow, North to South, is a 9 km long ridge, starting from Kodakkalparai in the North and terminating at Peimalai Mottai, (1582 m above MSL) one of the tallest peaks in the area. The precipitous slopes on the eastern side of the ridge hold a fair population of tahr. Southwest of the bungalow there are two hills — The Veilkathan mottai and Sambaltheri both of which also support tahr populations. The Kodakkalparai area is visited by the tahr mainly during the north-east monsoon, that is, October to December. At all other times the tahr keep to the other slopes mentioned above. Because of severe persecution at the hands of poachers the tahr remain in the middle terraces, even on the eastern slopes and go further down for grazing. It was here that the tahr were seen.

The tahr area is limited and was surveyed by Mr. A. J. T. John Singh between 15.v.76 and 17.v.76.

The Count

	Saddle Back	*Brown Buck*	*LBM & AF*	*Yearling*	*Young*	*Total*
Ridges close to the Bungalow	1	4	1	—	—	6
Variaattupallam	—	3	21	—	—	28
Sambaltheri	1	—	1	—	—	2
Veilkathanmottai	—	1	9	—	5	15
						51

Duplication was unlikely because the animals seen were well away from one another and counting was done within a short span of time.

The other possible tahr terrain is the southern slope of the ridge running from Peimalai Mottai to the West where Mr. John Singh's guide Aagasam had seen tahr previously. The terrain of the eastern slope of the Mudaliar Oothu — Peimalai Mottai ridge is such that smaller inaccessible pockets are likley to be there supporting small populations of the tahr. Taking all this into consideration the tahr population at Mudaliar Oothu could be estimated at around 70.

b) *Funnel valley and Vellakkaltheri* (*9°25′ N and 77°28′ E*). Mr. John Singh's report.

The 'Funnel Valley' and the Vellakkaltheri are in the hills West of Rajapalayam. The area was surveyed between 22.v.76 and 24.v.76 and only in Vellakkaltheri tahr were seen.

Saddle Back	Brown Buck	Adult M Adult F	Yearling	Young	Total
—	4	7	3	1	15

Two mornings were spent in the 'Funnel Valley'. No tahr were sighted. But during an earlier trip tahr were seen there.

Estimated population: 90—1976.

c) *Puliangudi Hill* (*9°10′ N and 77°15′ E*).

Puliangudi is further south of Rajapalayam. The hills, which continue in an unbroken chain south of Srivilliputtur are to the west of the town, which is on the Madurai — Tenkasi road. The escarpments on these hills held tahr in fair numbers in the olden days. The District Forest Officer of Tirunelveli Mr. Kadakshamani made extensive enquiries and came to the conclusion that they have been wiped out or had moved away. But Mr. J. J. Mangalraj, the Wildlife Warden of Mundanthorai sanctuary feels that some stragglers may be still left as a poacher was apprehended with a slain tahr in the area.

Ashambu Hills

At the southern extremity of the western ghats are the Ashambu hills spread over Tamil Nadu and Kerala States. On the Tamil Nadu side, the range is more or less equally divided between Tirunelveli and Kanyakumari districts. The Tirunelveli section is generally referred to as the Singampatti hills as it formed part of the former Singampatti Zamindari. A motor road cuts across a section of the hills from Kalladaikurichi in the plains in the east through Manimuttar and Manjolai estates of the Bombay Burma Trading Corporation in the hills and terminates abruptly at the valve house of Kodayar hydroelectric project where it meets the 4 stage winch from the Kodayar power house below, a total distance of 55 Km from Kalladaikurichi. From about half way up the hills the road traverses sections of Kalakadu forest, a fine example of tropical wet evergreen forest. Kalakadu is reputed to hold one of the largest populations of lion tailed macaque. (*Macaca silenus*) Map ref. 8°30′ to 8°35′N, 77°20′ to 77°25′E.

Panchamthangi Malai:

At the entrance to the hills is Panchamthangi malai (also called the Muthalathi malai after the Muthalathi river rising in this region) an off shoot of the Ashambu hills. Panchamthangi malai is a promising tahr habitat and is reported to have supported a fair population of tahr. Minor forest produce gatherers whom I met on my first trip in May 1976 reported having seen some tahr when they camped there a month previously. Vellimalai is adjacent to Panchamthangi. During my April 1977 trip my assistant Bokkan stayed behind to survey Panchamthangi. On 20th and 21st April, accompanied by two local guides he camped on Panchamthangi and covered that hill as also Vellimalai. They sighted 6 tahr. Bokkan thought he could have seen more had the grass been shorter. But the signs did not indicate a large population. His estimate for the area is 20.

Varaiattu Mottai:

The rocky slope to the right of the ghat road as one motors up into the hills and its crown are called the Varaiattu mottai, meaning tahr hill. My guide Poolappan, a supervisor in the employ of the Bombay Burmah Trading Corporation, who had been acting as a shikar guide in the area for over thirty years and others who are familiar with the area report that Varaiattu mottai was a favoured tahr haunt. Poolappan last saw (over ten years ago) three animals —the remnants of the tahr herds that once lived there. The knowledgeable people in the area attribute the disappearance of the tahr to poaching, the main culprits being members of some affluent families in the district. With control over poaching after the formation of the Mundanthorai sanctuary, tahr have a chance of coming back and re-establishing themselves. The entire area now falls within the Kalakadu sanctuary.

Kuliratti Mottai:

On the eastern face of the main range at an elevation of 1000 m is Sengaltheri where a forest rest house is situated. A bridle path leads to Sengaltheri from the Kalladaikurichi — Kodayar road. Sengaltheri could also be approached directly from the plains below. Kuliratti Mottai (1300 m) is 2 Km south east of Sengaltheri. It was Mr. Ramanathan the wild life warden of Kalakadu sanctuary who brought this tahr habitat to my notice. Unfortunately it was after my visits to Singampatti. His forest guards reported having seen half a dozen tahr at Kuliratti mottai. Mr. Ramanathan and Mr. Rauf Ali, a primatologist visited the ridge in 1977 at my request but could not make much progress along the ridge because of rank overgrowth.

Pechiparai Cliffs:

The name Pechiparai has come to refer to a much larger area on account of the large irrigation reservoir bearing that name that has been formed at the foot of the hills. The road to the valve house terminates at the cliffs, cutting them in half, vertically. Tahr have not been seen above the road after its formation. The tahr habitat which is generally known as Varaiattu mottai is bounded by the road on the top, the trolley line to the Kodayar power house on the north, thick jungle on the south and the plains below and covers an area of about 8 sq. Kms. In spite of these restrictions the tahr have a fine country to roam. The grasslands are extensive enough to support a fair tahr population. The valve house is placed at an elevation of 1266 m. above M.S.L. and the tahr country ranges in elevation between 700 and 1200 m.

On my first visit to the area in 1969 I saw six tahr, which were, probably, part of a herd. They appeared to be much harassed. A case of poaching by police guarding the Power House was brought to my notice. Mr. J. C. Daniel of the Bombay Natural History Society saw a herd of twelve in 1970. On 16.v.1976 Poolappan and I failed to see any tahr. But came across very fresh droppings. A family of workers walking all the way up from the Power House along the trolly line reported having seen some lower down. The following day a herd of 14 was sighted and I kept them under observation from 8.30 a.m. until 1.30 p.m. The herd was composed of 2 young, 3 subadults and 9 adults. Besides this herd the track of a large tahr, possibly a brown buck/saddleback was seen. Men from a workers' camp a Km away confirmed having come across this herd often. Rock blasting, loudspeaker noises, noisy music from the electricity board camp below were heard clearly on the tahr hill. There was activity both above and below and also on the trolly line. Despite this the tahr remained unconcerned. There were no reports of poaching this time.

Kalamala:

There is a fine range of hills overlooking the Kodayar power house. It is called by different names at different points — Varaiattu mudi, Paivarai kattu, Aduppukal, Venkalamalai, Kalamala and Mahali. It could be approached either from Kodayar power house at the foot of the hills or the valve house above. The starting point is way down the hill at the point where the first stage of the winch terminates. This range falls partly in Kerala State and partly in Tamil Nadu. This tahr habitat was first brought to my attention by Mr. G. Mukundan of the India Forest Service, Kerala cadre.

On 16/17.v.1976, on my visit to Varaiattu mottai I kept a good part of the range under observation for 3 to 4 hours each day. No movement of tahr was observed. On 17.v.76, Poolapan and a local labourer, who was familiar with the area, climbed varaiattu mudi (4679′) the first highest point in the range and looked for tahr. They sighted only three but came across piles of droppings. It was arranged for Polappan to camp there and take a better look, which he did in June 1976. He reported having come across 2 herds; 13 (8 adults and 4 young and yearling) and 9 (7 adults and 2 young), altogether 22.

On 18 and 19.iv.77 I camped on Kalamala with Bokkan and two local guides and covered the entire range. On Varaiattu mudi we came across only two adult tahr. Fifteen were seen near Aduppukal 1900 m (6132′). On the 18th—15 (2 dark brown males, 10 adult females and light brown males and subadults and 3 young) and on the 19th—8 (6 adult females and light brown males and 2 young), in all twentyfive were observed.

Seeing the piles of droppings on the top Mr. Mukundan thought that there should be over one hundred tahr there. There are also some tahr scrapes — erosion patches caused by tahr, one of them is so prominent that, seen from the valve house, it looks like a road cutting. Two winch operators who had seen service there for many years had not seen tahr on the section of the ridge overlooking the power house except on two occasions. The tahr in the range appear to be concentrated along the ridge, as the grass lower down and on the adjacent slopes is tall and coarse. Droppings and signs of tahr activity over a small area gives one the impression of a large tahr population.

One of the winch operators had seen small herds of tahr cross the trolley line on only two or three occasions from one side to the other, during the entire period of his 15 years' service.

Estimated population: 70—1977.

TIRUVANNAMALAI PEAKS

Motoring along the Tenkasi-Kanyakumari trunk road, while nearing the town of Panaigudi, two prominent rocky peaks come into view on the west. These are the Tiruvannamalai peaks (8°23′N and 77°32′ E). The peaks are in the Boothapandi forest range of Tirunelveli South forest Division. This is the southernmost habitat of the Nilgiri tahr. There are four tracks leading to the peaks; from Panaigudi, Roachmapuram and Thirukkurungudi. It is a 11 km. long trek including a final steep climb of 2 km. The fourth is a short cut from Rajapudur, which is very steep.

The Thulukkambarai river flows on the north western side of the northern peak. This is the usual campsite. On 8.v.76 at 18.45 hours from the camp itself one male tahr standing silhouetted against the sky on the northern slope of the northern peak (1596 m) was spotted.

The base of the northern slope is steep and boulder strewn. The vegetation was chiefly composed of *Phoenix sylvestris, Themeda cymaria.* On 9.v.76 besides the adult buck seen the previous evening an adult female and a young tahr were also seen there.

On the south peak (1587 m.) fresh young grass was sprouting after a recent fire and tracks and pellets of tahr were everywhere. A poaching party was skinning two tahr—a brown buck and an adult female on a slope! There were nine men including a Forester and two police men! It appeared that they had been camping there for three days and only that morning did they succeed in killing three out of a herd of 40 tahr, firing 10 shots. They were able to recover only two animals and the third had fallen into a deep gully which was inaccessible.

As the poachers had disturbed the area it was not possible to see any tahr on the Southern slope. But from the abundance of pellets and tracks it is possible to estimate that there must be 40 to 50 tahr in the area. Mr. John Singh deserves praise for undertaking the survey of this tahr habitat.

Estimated population: 40 + — 1976.

TAHR POPULATIONS — A SUMMARY

Tahr habitat	Estimated population
1. The Nilgiris	450
2. Silent Valley	30
3. Siruvani Hills	20
4. Elival mala	20
5. Nelliampathi Hills	25
6. Topslip and Parambikulam	120
7. Eastern slopes of the Anamalais Hills	125
8. Grass Hills in Anamalais	200
9. Amaravathi slopes	130
10. Swamiamalai Karadu	20
11. Eravikulam and Rajamallay	700
12. Less known plateaus— High Range	30
13. Palani Hills	60
14. Highwavy Mountain	100
15. Srivilliputtur and Rajapalayam Hills	90
16. Ashambu Hills	70
17. Tiruvannamalai Peak	40
	2230

NILGIRI TAHR HABITATS — AN APPRAISAL

1. **Nilgiris:**

a) *Western slope* — Ideal Nilgiri tahr habitat and extensive grasslands. Further encroachment into tahr country by way of wattle and blue gum plantations and hydro-electric projects to be avoided. Large population but somewhat stagnant. Point to be watched against poaching — Nilgiri peak area beyond Terrace Estate; Western catchment dams 2 and 3 above Emerald Valley Estate; Kinkerai Hundi, from Badaga villages in the Kundah area and Nadgani, from across the border through Sispara pass and over the cliffs from below Nadgani. The last is the furthest and most seriously affected area. Predators — tigers, leopards and wild dogs are active.

b) *Northern slopes* — Glenmorgan — Typical tahr habitat. Cattle grazing and other disturbances on the plateau. Slopes and cliffs less disturbed. The small herd here appears to have become extinct. Suitable area for re-introduction of tahr provided their protection can be ensured.

c) *Southern slopes* — Isolated locations. Restricted and much human activity has developed around the base and sides. No tahr left. Unsuitable for reintroduction.

2. **Silent Valley**

a) *Hills at the entrance of the valley near Mukkali* — Only stragglers, if any, left. Human activity in this area is increasing day by day. If Silent Valley project is taken up there will be lot more disturbance. However, after the project is completed some of these hills would make suitable sites for re-introduction of tahr if adequately protected.

b) *Ankinda Mala and adjoining hills* — Ideal habitat. Migrant population. No human disturbance except poaching. Poachers have access to the area through the Sispara Pass and over the cliffs below Nadgani. Co-ordinated action from the Nilgiris plateau as well as from Kerala is necessary to check poaching.

3. **Siruvani hills:**

a) *Kunjera mala ridge* — Small population. Endangered habitat due to erosion and rank growth. Disturbed conditions below due to dam work. Close watch necessary.

b) *Vellingiri malai* — Good tahr country. But no tahr left. Suitable for re-introduction.

4. **Elival mala:**

a) *Palamala* — Fair sized habitat. Small population recovering after heavy poaching. Close watch necessary to prevent recurrence. Promotion of legitimate activity advocated.

b) *Karimala* — Limited habitat. Optimum population. Could eventually be encouraged, through proper protection measures to spill over into Kondamala, the extensive grass covered ridge and slopes to the South.

5. **Nelliampathi hills:**

a) *Hill top* — Ideal tahr habitat and extensive grasslands. Heavily poached. Seriously endangered population.

b) *Cruz malai and Chinna aatu malai* — Fair sized habitat cattle grazing and disturbance. Endangered population and endangered habitat. The planting company there could be encouraged to co-operate and involve itself in conservation.

c) *Govinda malai* — Stragglers, if any. Endangered.

6. **Topslip and Parambikulam:**

a) *Pandaravarai* — Adequate population for fair sized habitat, which is endangered through erosion and over grazing by gaur.

b) *Kolumbumalai* — No resident tahr. Endangered habitat — soil erosion through action of worms.

c) *Perunkundru* — A very fine habitat; extensive, good grazing and well protected. The long grass covered slope to the south also holds promise and can absorb the spill over.

d) *Palagakundru* — Small isolated habitat — small population.

e) *Vengoli malai* — Long narrow ridge. Suitable for and holds a small population. In the middle of two sanctuaries and protected. Subject to predation.

f) *Karumalai gopuram* — Small but ideal habitat. Small population but area could hold more. Composition of the herd — male/female ratio — disproportionate. Translocation could be attempted to correct inbalance.

7. Eastern slopes of the Anamalai hills:

a) *Aliyar*—Low elevation habitat, fairly extensive—appears unpromising, but is supporting fair population.

b) *Chetta Guttu*—Ninth hairpin bend hill—No resident tahr. But of late a saddle back or two or a small herd of migrants from either direction seen frequently. Being close to highway require watching.

c) *Attakatti cliffs*—Once subjected to heavy poaching. Recovering slowly. Habitat could support some more.

d) *Thadaganachi malai*—Medium level habitat. Fairly extensive. Comparatively small population for the area. Danger from cattle grazing and disturbance. Danger from poaching-requires close watch.

e) *Navamalai*—Low level habitat. Looks unpromising but supports a fair population. Extensive cattle grazing except on cliffs.

8. Grass Hills in Anamalais:

Ideal habitat, extensive. Large population. Herds move all over the range and not restricted to specific areas. Advisable to keep the presence of the planters in the Grass hills through the Konalaar Fishing Association as a deterrent to poaching by estate labour and raids by Muduvans across 'no man's land.' A dam across Konalaar is under survey. If this is taken up considerable damage will be caused to the environment and tahr will be driven into the "No man's land" where they will be subject to poaching.

9. Amaravathi slopes:

a) *Jambukal*—Endangered habitat and population. No hope.

b) *Erumai malai*—Low level habitat. More a scrub country than a normal tahr habitat. Supports a fairly large population for an area of that extent. Preservation adequate.

c) *Elumalaiyan koil hill*—Medium level habitat. Fair population, but subjected to poaching.

Hills higher up. Promising country. But subjected to poaching. If controlled, suitable for re-introduction.

10. Swamiamalai Karadu:

Small population. Endangered.

11. Eravikulam and Rajamallay:

Ideal habitat. Extensive and well preserved except on the periphery. Heavily populated. Periphery requires more attention.

The "No man's land" between Grass hills in Anamalais and Eravikulam is an equally good habitat and has great promise. Efforts to check poaching by introducing legitimate activity necessary.

12. High Range—Less known plateaus:

Tertian's plateau Karunkulam Periavurrai	Typical tahr country. But limited area. Small populations. Endangered. Very little hope.

13. **Palani Hills:**

Extensive and ideal tahr country on the Southern face of the Upper Palani plateau. Encroached upon by cattle and forest plantations from above and coffee and cardamom plantations from below. Classic case of endangering habitat leading to decimation of wild life. Small scattered populations leading precarious existence. Scattered restricted habitats also suffering from same fate. Massive conservation effort required for rehabilitation. Little hope of such effort as things are.

Adukkam range: Good country, but now lost for the tahr.

14. **Highwavy mountain:**

Mixed grassland/forest habitat. Widely scattered, supporting small herds. Endangered populations.

a) *Metla*: Fair sized, subject to cattle grazing at lower levels. Also poached from below.
b) *Varayattu mottai*: Limited habitat. Much disturbed due to hydro electric project work. Endangered habitat and population.
c) *Attu mottai*: Cliffs afford some amount of protection. Poached.
d) *Plot No*. 28: Fair extent of grass and rock country. Bottom end adjoining Rajapalayam hills. Subject to poaching.
e) *Kudamparai*: Isolated. Present position not known. Due to scattered populations access to tahr country is a problem. Effective protection at the top at least is possible and must receive immediate attention.

15. **Srivilliputtur and Rajapalayam hills:**

a) *Mudaliar Oothu*—Extensive and ideal country. But due to habitat disturbance tahr movement is restricted. Scattered locations, could be connected once extensive cattle grazing and poaching are removed. Promotion of legitimate activity is advocated as supervision is otherwise difficult. Area holds much promise; if conserved.
b) *Rajapalayam hills*—Limited tahr country. Gravely endangered. Very little hope.
c) *Puliangudi hills*—It is feared that the scattered populations on these hills have been exterminated.

16. **Ashambu hills:**

a) *Panchamthangi malai*—Fairly extensive habitat, comparatively small population for the area. Fairly well preserved.
b) *Varaiattu mottai*—No tahr left. Suitable for re-introduction.
c) *Kuliratti mottai*—Note an ideal country. Small herd.
d) *Pechiparai cliffs*—Limited habitat. Small but growing population. Well preserved.
e) *Kalamala*—Extensive grasslands bounded by cliffs. Signs indicate a larger number than actually seen. Holds promise.

17. **Tiruvannamalai peaks:**

Fairly extensive habitat. Ill preserved. Subject to poaching and cattle grazing. Possible to eliminate both if determined efforts are made. Fair population. Holds promise.

OBSERVATIONS

1. *Is Nilgiri tahr an endangered species?*

The overall population of the Nilgiri tahr; its hardiness and adaptability; flourishing tahr populations in certain habitats in its range and the breeding potential of the species as observed and reported herein do not qualify the tahr to be included in the list of endangered species. However, there is no room for complacency. Some of the scattered populations are, not only, endangered but gravely so and could be expected to disappear in the not too distant future.

2. *Conservation*: There are two recognised methods of preserving a wild animal—total protection and management. Which of these two methods is to be employed in the case of an animal like the tahr?

A study of the reports on the seventeen groups of Nilgiri tahr habitats is revealing. Only two of the seventeen areas, namely Eravikulam and Nilgiris have sizable populations. It is significant that both these areas were shooting preserves under the control and management of Game Associations until recently. The associations concerned believed in preserving game through management by regulating their pursuit.

Grass hills in the Anamallais has the third largest population. Grass hills were also, in a sense, a game preserve of the Anamalai planters. Their fishing/hunting lodge is located in the heart of the tahr country and their presence was felt. Palani hills were the only exception. But the Game Association there ceased to exist, except in name, after the forties.

Going back into the history of the principal tahr habitats one finds that the stock of game was low when the Game Associations took over. They had to start almost from scratch.

But for the Eravikulam game preserve and the Rajamallay sanctuary of the High Range Game Preservation Association and the presence of the Konalar Fishing Association in Grass Hills there is no doubt, that the "no man's land" in between, which has very little game due to depredations of Muduvan poachers, would have extended on either side to cover the whole of Hamilton's Plateau.

As against the example of Nilgiris and Eravikulam there are instances of fairly well stocked tahr habitats which, although officially closed to hunting, no longer have tahr, the herds having been eliminated by illicit hunting and snaring.

If it is possible to rehabilitate the tahr in the Nilgiris from the verge of extinction (and possibly the harassed herds on Hamilton's plateau) it can be done throughout the tahr's range.

The rehabilitation, it must be remembered, was done mainly through regulating tahr hunting. It is also well to remember that sporting standards in these two areas and in the Grass Hills were rather high.

In Eravikulam between 1958 and 1969 an average of 1.9 saddle backs per annum were shot. In the Nilgiris between 1912 and 1939 an average of 4.6 saddle backs were killed. And between 1940 and 1976, 76 were bagged, an average of just over 2 per annum. There being no forestry operations in the tahr wilderness (with rare exceptions as in the case of some parts of Nilgiris and Grass Hills where some seasonal operations take place), no forest staff visit these places. This is where the role of the hunter assumes importance. A saddle back, which is permitted to be shot, is a difficult trophy to secure. Many trips are made into the tahr wildernesses to procure a single trophy. Then there are marking trips. This leads to regular patrolling of the area. To give an example, for six years the writer strenuously tried to secure a really worthy trophy before he gave up in favour of the camera. There is no doubt that the trophy hunter played a useful part in keeping poaching down in remote tahr country.

As far as the saddle back is concerned, roughly half of them are true solitaries and do not take part in breeding. Every saddleback legitimately shot, therefore, represents a substantial number of breeding stock saved.

In these circumstances the wisdom of transferring the Nilgiri tahr from Schedule II (special big game which can be shot on licence) to Schedule I (absolutely protected) of the Wildlife (Protection) Act 1972 (vide 5.10.1977 notification) is open to question. This is typically a bureaucrat's way out of a difficult situation by closing his eyes to realities.

Particularly, in a place like the Nilgiris, the cropping of a few old saddlebacks is not likely to have any effect on the overall population. On the contrary it will be a good conservation measure to have a few sportsmen visiting the tahr country on legitimate business. And supervision is simple. All one has to do is to check him out at the point of exit.

Unlike the tiger, which wears valuable fur which has universal appeal the saddleback offers a trophy which has value only to the hunter. As for the poacher who is after its meat it does not make the slightest difference whether the tahr is in schedule I or in Schedule II to the Act, as long as he eludes capture. Since he operates in remote and difficult terrain offering long range views effecting his capture is more easily said than done. The best thing to do is to keep the poacher out with legitimate presence. Dr. George Schaller recommends—

"The animals survive in the Nilgiris and High Range only because the local wildlife Associations have protected them for years for sporting purpose. In areas where tahr have not had the benefit of private initiative, where they have had to rely solely on the protection afforded by the State Government, they have either been wiped out or reduced to a few scattered herds. The revoking of shooting rights would eliminate whatever interest the Wildlife Associations have in the animal and the resulting increase in poaching and habitat destruction might well tip the balance of the species from tenuous security to extinction". [J.B.N.H.S. Vol. 67(3)].

In its own interest the Nilgiri tahr should be put back in Schedule II to the Act. Hunting when restored must be done selectively in areas like the Nilgiris, and in the "no man's land" on Hamilton's plateau with the express object of affording protection to the rest of the tahr population there. The opening up of the area outside of the Eravikulam National Park to hunting will surely encourage the restocking of the area through spill over of the excess stock in Eravikulam. As for smaller tahr habitats, which can be watched and guarded, they should remain closed and closely guarded. There, the removal of even an old saddle back might upset the balance. Thus both methods of conservation namely, total protection in smaller areas and sanctuaries and management by regulating hunting in larger areas are advocated.

Administration: Consequent on the enforcement of the wildlife (protection) Act 1972 forest departments in the states have been bifurcated into general and development wings under separate Chief Conservators of forests, wildlife being placed under the development wing. In practice this progressive measure is leading to compartmentalisation which is rather unfortunate.

Wildlife wardens have been appointed and placed in direct control of sanctuaries. Although technically the administration of the Act outside sanctuaries is also the responsibility of the wildlife department, with limitations of staff, wildlife wardens are not in a position to exercise effective control over areas outside sanctuaries. Further, as they have been vested with 'territorial powers' over sanctuaries, which used to be exercised by the general administration, their energies tend to get dissipated in this direction. Wildlife which even otherwise had a low priority has been pushed further down in the list of priorities as far as the general administration is concerned. The cumulative effect of all these developments is that wildlife in general and tahr habitats outside sanctuaries in particular get a poor deal.

The tendency to treat the wildlife department as a poor relation of the general administration as it is a poor earner of revenue does have a demoralising effect on the men. This tendency must go. The wildlife staff must be made to feel important and wanted by giving them every encouragement possible. This was probably one of the reasons for handing over administrative control of sanctuaries to them. Needless to add that there is no reason why the wildlife men should feel neglected. As professionals doing a specialist job they have the opportunity to prove their worth. And pride in the profession, in itself is a reward.

4. *Stagnating population*:

It has been observed that tahr populations, however well preserved, however vigorous and however high the birth rate start stagnating once certain levels are reached. Unfortunately, there is only the Nilgiri records to base this assumption. Phythian-Adams (1929) thought that there were 400 tahr in 1927 and over 500 in 1930 (1939 report). Although these were 'guesstimates' based on insufficient data, in view of Phythian-Adam's field experience, they do give one a rough idea. The 1963 census of the writer yielded a figure of 400 (approx). Schaller who did a spot check of a third of the area in 1969 thought that the population had stagnated. The writer's 1975 census yielded a figure of 450. These various estimates seem to indicate that the tahr population in the Nilgiris levelled off at a little over 400.

From accounts of hunting expeditions of Pollock (1894) and Hornaday (1885) in and around Thunakadavoo (between Topslip and Parambikulam) some rough idea of the tahr population there is gained. Even in a well preserved and ideal habitat like Perunkundru there has not been any spectacular increase in the past 70/80 years.

Grass Hills, Topslip and Parambikulam, Eastern slopes of the Anamalai hills and Amaravathi slopes are situated within the Anamalai wildlife sanctuary which was formed in 1973. Some of these tahr habitats were closed to hunting since 1970 or so and have been fairly well preserved. In spite of this there has not been any significant increase in population.

This matter of stagnating population, it would appear, is not an isolated instance but a general trend. In the case of the Nilgiris there is atleast a fair amount of predation. But in some of the other areas there is hardly any predator activity worth mentioning. There is, no doubt, some falling off of numbers between the young and sub-adult stage and the sub-adult to adult stage. But it is not a steep fall.

Therefore, in the natural sequence of events, the total population of Nilgiri tahr ought to have been much more, at least in undisturbed and well preserved areas, than what the status survey has disclosed. It would be worth investigating and identifying these inhibiting factors. Reintroduction into former habitats could be considered provided their preservation could be ensured. With modern capture guns that are in use translocation should not present a problem.

5) *Captive breeding/ranching*:

An interesting finding in the "discovery" of flourishing tahr populations in "low country". Going into old records it is seen that at one time tahr had flourished even in the plains. Jerdon (1874) in MAMMALS OF INDIA came across a tame herd in a church compound in Cochin. Frederic Cotton (as referred to in 'Notes on Jerdon's Mammals of India by an Indian sportsman') confirms this. The tahr in the Trivandrum zoo are doing well. The low country tahr would appear to be more browsers than grazers. In this context it may be mentioned that the writer has undertaken an ecological study of the low country tahr, which it is hoped will throw some light on the ecology and behaviour of the low country tahr and Nilgiri tahr generally.

To rehabilitate the tahr it would not appear to be necessary to seek high altitude, temperate locale with extensive grasslands bounded by cliffs, where supervision and control are a problem because of remoteness. Any rocky hill with mixed browse and grazing would seem to do. In other words, any area which is capable of supporting domestic goats—which, incidentally, are efficient converters of browse into protein, a quality the tahr possibly shares with the goat—would be able to support tahr.

This knowledge has thrown open exciting possibilities. Captive breeding is possible. Ranching also has scope. And this in country unsuitable for more demanding forms of wild or domestic ungulates. In choosing suitable areas, locations where preservation presents no problems can be chosen.

CONCLUSION

There is, no doubt, concern for the conservation of the Nilgiri tahr. But so for this concern has not gone beyond labelling it an endangered species, upgrading it to schedule I to the Wildlife (Preservation) Act, declaring some of its habitats, sanctuaries and passing impressive administrative orders. It takes much more to preserve an animal like the tahr which inhabits remote mountain peaks beyond the reach of the ordinary conservation machinery. Physical effort, a certain amount of dedication and a pragmatic conservation policy is what is required. In planning strategy promotion of legitimate activity in tahr country to displace and discourage illegitimate activity must have priority.

AN APPEAL

As mentioned before, it is my hope to make the survey a continuing process and information which will update it periodically is welcome. Any tahr habitat which does not find a place in this report may please be reported for investigation.

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PEREGRINE FALCON

S. M. Osman[1]

(*With a plate*)

Of all the true passage peregrines, one that travels the longest distance during the course of its yearly migration, is the Tundra falcon, *Falco peregrinus calidus*. It breeds well within the Arctic circle and flies down south to the Persian Gulf area and beyond right upto the southern gates of Arabia. In rare cases it may even cross the Red Sea to enter Africa but this is not firmly established yet.

One has only to listen to the voice of Taymur Mirza, that legendary Persian falconer whose name is still a household word in the falconry circles of Iran, when he speaks in his famous treatise on falconry, to fully appreciate the qualities of this bird from a falconer's standpoint. In his book, he describes it as the yellowish almond coloured variety of the 'Behri' or the peregrine falcon. Our famous chronicler unacquainted with our modern scientific terminology, simply calls this bird the '*Rumali Shaheen*', and continues, "I have trained these peregrines to gazelle." Nevertheless he laments, "they are however delicate birds, bold and daring; they dash themselves impetuously against the gazelle's horns and thus frequently injure themselves fatally."

Having studied these falcons in captivity, and also having watched, over a considerable period of time, wild *calidus* falcons, I am absolutely convinced that accidents of the nature described by our worthy Taymur Mirza cannot alone be attributed, to their daring impetuousity as he calls it, but mainly to the style and tactics adopted by these birds when hunting game.

We had a large immature female *calidus* peregrine and out on the hunting field, time without number I have watched spellbound the vertical dives made by her when pursuing game. As soon as we had indication of small game (partridges) in the area we were quartering, the falcon would be unhooded and cast off the fist. She would immediately rise straight up to a height of three to four hundred feet and would maintain that ceiling not by glide soaring as is usually the practice with other peregrine's, but by racing back and forth above our heads till we got to flushing the quarry out of cover. She would then be seen descending in an almost vertical power dive on to the illfated target. I never tired of watching this fantastic performance by her. There was hardly any question of pursuing game for it always was a bolt from the blue leaving little if any chance at all for the hunted to escape. As you may have guessed, there did occur on several occasions some nasty accidents. I remember a time when a recalcitrant stone curlew refused to be flushed but would merely streak out on foot from the sanctuary of one lot of bushes to the next. Ultimately the peregrine tired of following its movements from up above and waiting for it to take wing, and so the next time the curlew raced from under one lot of brambles the falcon made a dive for it. When just about to be smitten by the peregrine, the curlew gingerly side stepped and the falcon landed at full force on the dry sandy river bed. It was only then that the wily curlew to take wing, leaving behind a dazed and much shaken falcon. The impact was so forceful that the falcon after it had been collected from the ground just sat groggily on the fist for a long time. An adult female *calidus* falcon will normally run upto one pound and fifteen ounces in weight when directly taken from the trapper's net.

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As a falconer my experience is that female birds fly best when they stand one pound twelve ounces in weight. Though heavy, they are always very keen, and will tackle almost any feathered game suitable for them. The principle to keep in mind about these falcons when attempting flights at game, is ofcourse to have them flying not above four hundred feet, as otherwise they would be inclined to wander away farther afield. In any case, because of their inherent tendency to executing power dives after whatever game they are being flown at, chances of a surer kill would be all the more, if the flight ceiling for these falcons at such times is restricted to 250/300 feet only.

Since these falcons are not very much disposed to soaring and 'waiting on', as the term goes, for any substantial length of time, one method to hold them in check, and from wandering and leaving the falconer, when they are flown or exercised, is to keep calling them constantly so that they keep lurking not far from the falconer, and also to intermittently swing the lure. If good sport is to be expected it will be imperative to have the falcon up for no longer than a few minutes at a time only. In the meanwhile the falconer or his assistant should be able to flush game from cover.

From all this it becomes clear as to why Taymur Mirza's falcons generally got pinned on gazelles' horns when out hunting this small antelope. Nevertheless wonderful and successful flights may still be had at owls, kites, plover, partridges, cranes, magpies and some other birds as well. This falcon is a specialist of the first order and all that is required is the falconer's cooperation. Foremost point of great significance in the matter of flights is to have the quarry, as far as possible, directly below the falcon, at the moment of it being flushed out of cover. Alternately flights may be obtained when the falcon is cast from the fist at game. In such flights both hunter and hunted mount the sky in a series of what to the observer appears to be never ending spirals, till the falcon manages to gain higher elevation, rising well above the quarry. From then on spectacular series of stoops, all in quick succession, mark the beginning of the end for the illfated prey. In these mid-air strikes is clearly seen the vertical nature of plunging dives which generally is absent in other types of peregrine attack strategy.

For the benefit of the aspirant falconer, a description of the *calidus* peregrine in its juvenile state is attempted. In the adult or haggard phase there is little to distinguish this bird from its counterpart *peregrinus peregrinus*, or *peregrinus brevirostris*. falcons. After two or three moults, it becomes very difficult, even for the most experienced observer to be able to differentiate between it and the other passage peregrines of the same age group. Should at such times classification become necessary, careful examination of the falcon's attack and specially stooping pattern, ought to be made, Thereby alone will be seen the only indication that could possibly identify this falcon from the rest of the tribe.

A juvenile *calidus* peregrine has a frontal band of light yellow running across the forehead that extends almost half way round its head. It has yellowish brown mustachial stripes, broadbased under the eyes and tapering down to a blunt end on either side of its neck. Crown of head and nape are light brown in colour with dark brown shaft streaks. Back feathers and wing-coverts are brown with flesh tinted spots and very pale edgings. Its rump and upper tail-coverts are pale brown, or cinnamon coloured, and obscurely banded. It has a greyish brown coloured tail with oblong cinnamon marks and a whitish pink tip. It also has dark bands running across it. In addition to this there is a prominent cinnamon spot under the chin and light brown streaks from below its chin to the area denoting its crop. All over the breast which is wheat coloured, are spread tear-drop shaped spots. Its feet and cere are grey yellow in colour but this, as any falconer will be able to tell you, is at very best a misleading factor, since colour of feet and cere will alter with the type of food a falcon has been feeding on. Usually food that is rich in vitamin B12, brings out a deep orange colour. On the sides and on the thighs are seen heart-shaped light brown spots. These diminish in size as they appear lower down on the falcons thigh extention. This falcon has, as in the case of most other falcons, very dark brown eyes. Its orbital lids are mostly light yellow in colour.

A *calidus* tiercel generally weighs sixteen ounces. One such falcon had strayed into the Gangetic plain. He was in his juvenile plumage, and was brought to me by a bird merchant who knew I was fond of hawks. Indeed he was a very pretty fellow and was the first tiercel of the kind I had so far come across. In the past I had seen and handled a number of *peregrinus peregrinus* tiercels but never before a *calidus* tiercel had come my way. However I was acquainted with female *calidus* falcons. I therefore very promptly bought the tiercel hoping to send it to an English friend in England. At the time of buying him I noticed one of its middle toes to be badly scarred with the hard scab still adhering to the wound which had luckily dried up by now. I assumed this mark to be due to the ravage of some of the bigger kind of parrots which are often preyed upon by falcons and are in addition plentifully available in this area. However many months later I was able to get to the bottom of the story.

The hawk dealer pointed out that he had known the tiercel for quite some time and had tried his utmost to lure him to his trap but to no avail for it would not oblige by flying down to his net no matter what bait he used. It was by sheer accident one day that the falcon dived out of the sky to grab a pigeon out of his neighbours pigeon loft. Perhaps the tiercel miscalculated its rate of descent, or maybe he was so engrossed in capturing a pigeon that he did not notice the corrugated iron protrusion of the roof by the side of the loft. This bit of tin sheeting hit the tiercel's outstreched claw. The tiercel then, I was told slammed with a resounding smack, into the side wall of the building, and thus with all the wind knocked out of him he fell into the courtyard in a dazed condition. Snatching up a bedsheet that had been hung up in the yard to dry, the owner sprang with, as he later told me, much alacrity, and threw the sheet on it before the dizzy falcon could make good its escape. Later the falcon was brought and sold to me. And so the injury to its middle toe.

On looking back I was able to reconstruct the entire episode. The falcon by virtue of its peculiar habit was not accustomed to flying low in a shallow dive at game or bait tied behind the trapper's net. Capturing a *calidus* peregrine is more or less a matter of chance than a deliberate lure and capture operation by any trapper. Though I have not tried it, I believe however that "Barak" method of capturing falcons would stand a reasonable chance of success in catching these falcons. No wonder Punjabi falconers dislike this peregrine, or the "yellow behri" as they are wont to call it. After having tried and attempted all the various stratagems and tricks known to these worthies, our Punjabi trappers get exasperated, to the point of shouting abuse at the falcon, for its lordly indifference to all the different baits offered by the trapper in the vain hope of getting the peregrine in to his net.

Having known something of his essential disposition in respect of vertical sky-diving at game, I was able to easily control the tiercel's training programme, and so in a very short time had him flying to the lure without any hesitation. In the beginning I would usually, when the falcon was just about to strike the lure, pull it away from him. The tiercel would then fly straight on, steadily gaining height till he would rise to some two hundred feet. Once more I would swing the lure and shout for him to return. He would immediately swing round to come flying over my head maintaining his height in the air. I would then promptly throw out the lure and the tiercel would immediately make a vertical dive for it. Whereas in the *calidus* peregrines such vertical dives are indeed a regular feature and an integral part and parcel of their nature, some other falcons can also be trained to execute a similar feat once in a while. However it is not easy to teach them this trick and not every bird will take to it.

I trained the tiercel and in a short time he was flying very well. One day while I had him out for exercise in the country, I saw, at the edge of the field I was walking through, a covey of grey partridges feeding. Immediately I unhooded the tiercel and cast him off my fist. Within no time he was up to his usual height of three hundred feet or so. In the meanwhile I had drawn close to the spot where the covey had scurried into a hedge. By this time the falcon was racing up and down the hedgerow, maintaining his height in the air. Next time as he came directly over my head, I bombarded the bushes with clods of earth I had picked, and shouted at the top of my voice. Pelting the hedge had the desired effect for all the partridges exploded out of the bush, and my hollering had alerted the tiercel, who stooped in a most spectacular manner. And before the covey had gained a few yards, the tiercel had hit one of the partridges which fell back into the hedge with a shrill cry of protest, and amongst a complete shower of its own feathers.

While all this was happening the rest of the covey had got scattered to settle in nearby bramble bushes, and the falcon ofcourse had regained its usual commanding height of three hundred feet or so. Now he was continuously flying back and forth over the spot where the partridge had landed in the hedge. Because the falcon was intended to go to a friend in England, though I had permission to train and hunt with it, I was reluctant to take any further chances with the partridges for it would have meant keeping the falcon up in the air till the partridges could again be flushed. I did not have a dog with me or a helper either, and I knew from experience that getting the birds to break cover now especially after a close shave with the tiercel, would be no easy matter. Anyway I had to keep an eye on the tiercel all the time and this could not be managed simultaneously.
Hence the tiercel was called back to the fist. With the falcon securely perched on my fist I attempted to unearth the injured partridge

which the tiercel had struck. This proved to be an impossible job, though there were feathers scattered all over the place where the partridge was last seen tumbling into the bush. Under such conditions a dog is very handy and if trained, will dig up the quarry that has gone to earth in ninety out of a hundred cases. Sometimes it may happen that a partridge in its blind fear to get away from the pursuing falcon will take refuge in some deserted warren. Under the circumstances even a dog becomes useless, and the enterprising falconer will have to slip his hand into the burrow or hole and reckon with the risk of being bitten by a snake.

The tiercel's end was tragic, for it never got to my friend in England. It was in March 1973 when I daily expected news of arrangements by my friend for the falcon's passage to England to come through that my mother met with an accident resulting in a fracture of the neck of a femur. As a result of this unfortunate incident all our attention was naturally devoted to her needs in the hospital, and I would come home only to feed the hawks (I had a goshawk, an eagle and, this tiercel as well). Within a week I noticed the tiercel going off his food, and it was only when I weighed him that I was shocked to find him much below average. Straight away I suspected worm infestation to be the cause for this loss of weight. When I examined the mutes my suspicion was confirmed, because there were tell-tale traces of blood in its droppings.

With the help of our local vet, I dosed him for worms. This unfortunately had the opposite effect to what I expected. The case was apparently too far gone for any medicine to be effective or of any value. In another few days the falcon threw up a cropfull of food, and the blood in his mutes was now present in great profusion. It now became abundantly clear that this was the beginning of the end. The end came soon afterwards on the next day or was it the one after next. As usual I woke to the Muezzin's call for prayer early and had just finished my ablutions when I heard the falcon's bells jangling as he fell off his perch in the adjoining room where he had been kept under observation. Prayers unsaid I hurried to his rescue but by the time I got to him he was already in his last throes. It was a great shock to lose him the way I did, and my friend in England must have felt it all the more, but he had unduly delayed its collection. I believe that with better means at his disposal for the detection of nematodes, he in England could have taken care and treated the tiercel right in the early stages when the disease was not at all evident to an observer without the aid of proper pathological assistance.

I presented the dead tiercel to Doctor Asketh Singh of the Zoological Survey of India who has kindly had it mounted and kept for display in the survey's museum hall. When the taxidermist opened up the falcon it was seen that the entire body cavity was teeming with helminths. Some had eaten their way into the air sack to appear in the lungs. A few were also present in the falcon's crop.

In 1943 my uncle obtained a female *calidus* falcon from the hawk market or what used to be the hawk market in those days at Amritsar, and which was run by Chowdry Mohamed Din Bazdar. This beautiful bird which was in her juvenile plumage, had the tip of her beak almost up to the portion of the barb missing. It had happened when an enraged trapper who had spent many hours in trying to lure the falcon to his net, had in the end in sheer desperation taken a pot shot with a catapult at her. This had smashed away her beak tip. The blow proved to be forceful enough to stun the peregrine, and knock her to the ground. There she lay helplessly and long enough for the trapper to nab her. The imprudent bird catcher who did not know that these birds never came down to catch prey tied to the ground behind a net, had been lucky in not having killed the falcon outright.

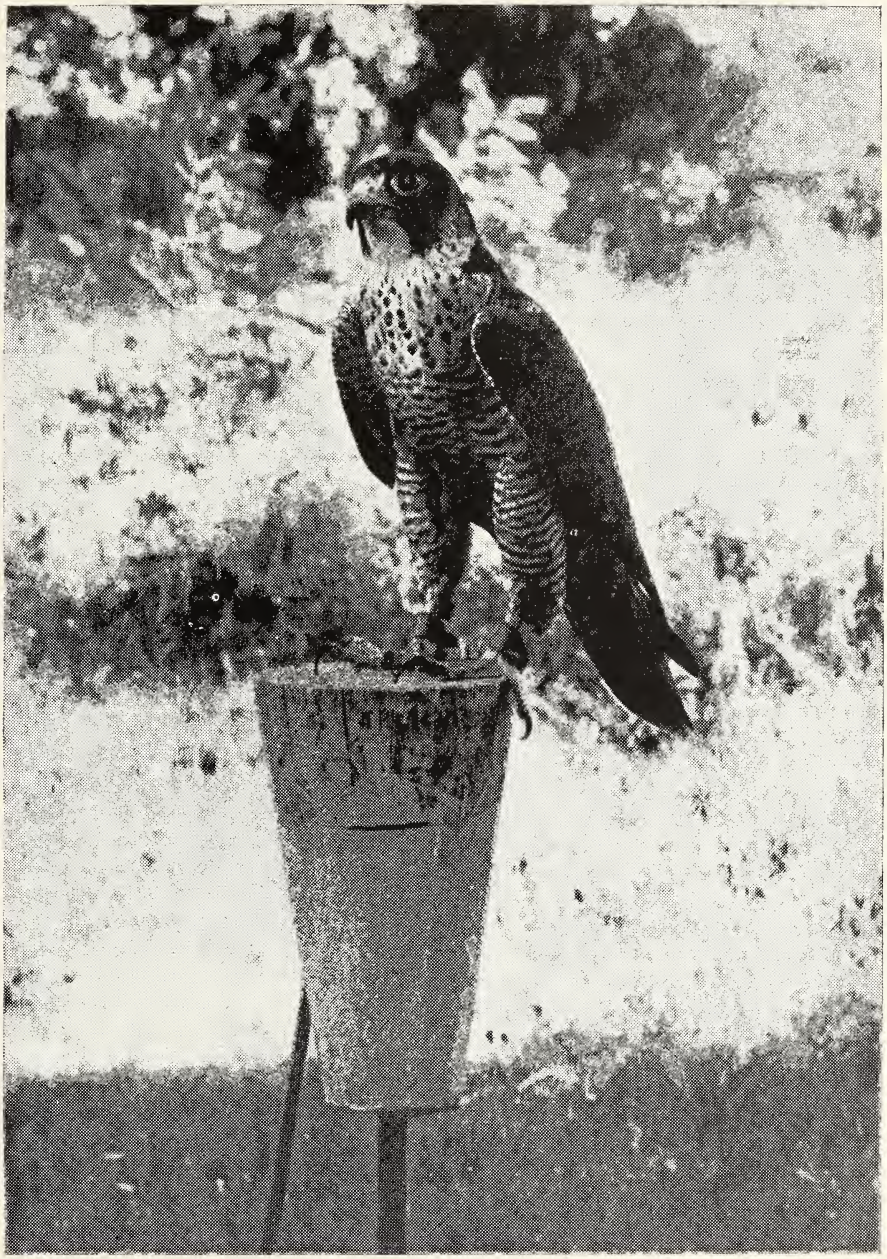
In a very short while its beak grew back to its normal length once again, and I am happy to say that she stayed with my uncle till she ultimately departed for the happy hunting grounds at the great old age of ten years. A falcon gets fully matured in almost two years. On the other hand it takes full twenty years or thereabout for a human being to attain all his faculties. This then multiplied by three will give the average human life span. Applying the same factor to that of a peregrines life span, we arrive at the conclusion that the normal age of a peregrine falcon should within reasonable limits be around six years. So according to human standards, the peregrine had lived to almost twice its average span of six years which again when translated in terms of human longevity comes to over a hundred years. Not bad even by human standards I should think.

In 1955 when I was doing land reclamation work not far from Satyanarian temple, on the Haridwar-Rishikesh road, I watched for over three weeks at a stretch, and in detail, the activities of a female, immature *calidus* falcon, During that period I had with me a trained adult *peregrinus peregrinus* falcon. Very close to my place of work there existed open country of a sort where hunting with a falcon was possible, I would be flying my peregrine at plover, partridges, stone curlew and at times just for the fun of it, at paddy birds, or the lesser kind of cranes, which generally go by the name of Herons. One day as my peregrine waited on high overhead, in anticipation of my flushing some game out of cover for her to dive and capture, there appeared out of the blue, this wild female *calidus* peregrine falcon. I was first made aware of the wild peregrine's presence by her harsh grating screeches as she started an aerial battle with my trained falcon.

Immediately I called back my peregrine which luckily disengaged from the action and stooped to the lure. Having secured my bird I looked up and watched with satisfaction the wild peregrine swing to perch on the dried limb of a giant tree standing on the bank of the Song River. The place where this happened is just below the railway bridge over the Song river on the Riawalla-Rishikesh link line. It also happened to be just a convenient half mile from the spot where I was camped at the time. From that day onwards and for almost three weeks later, the dead tree and the falcon on the river Song, remained objects of careful observation for me.

I was not at all very keen to catch this falcon at the time for I had a good trained peregrine to while away my spare hours, and yet the urge to capture this beautiful bird, and hold her in my hands even for a little while, for I definitely would not be able to hold her and train her as I had a lot of other work to do, besides keeping two falcons at the same time is no joke, tempted me to attempt its capture inspite of my better judgement. My untiring efforts as I had reckoned, were of no avail. The falcon stubbornly refused to come to the net which I first baited with a blue rock pigeon and later with a shrike I had got. I even tried with a tame partridge to entice her to fly down to the net, but nothing worked.

I usually got to the perch site at the crack of dawn and as often as not would find the



Falco peregrinus peregrinus (female), 2 years old.

peregrine busy on some kill or the other which she had brought to the perch prior to my appearance on the scene. Mostly it would be small water birds such as snipe, kingfishers etc. With the meal over it would naturally be meaningless to expect the falcon to show interest in whatever bait I was to put out for her behind my trap. On several occasions when the peregrine had not thrown up her cast till the time of my arrival on the site, I would patiently set up my net hoping she may fly to it once the cast had been thrown by her. Let me explain that a feather cast which is thrown out by all birds of prey is a ball of undigested feathers that the predator had swallowed in the course of its last meal. This pellet of feathers is disgorged by birds of prey just before sunrise every day. However if a kill has been made by a bird of prey late in the evening, and if the kill is some bird that is as big as say a pigeon, the predator will not then be able to digest the entire quantity eaten in the course of the following night. Till such a time as this is not accomplished, the cast will be retained. The cast remains in the falcon's gizzard along with bits of meat that the falcon or bird of prey took with its last meal. Here the digestive juices in the falcon's system would be actively engaged in the assimilation of the food matter. If in such a state the cast of feathers is expelled, and since this has to come from the gizzard, with it will also be brought up pieces of undigested matter in a most offensive condition, sufficiently repellent to banish all thoughts of dinner from the predator's mind for a long time to come. As a matter of fact bits of meat adhering to any bird of prey's morning cast is indeed a clear indication that all is not going well with it. However a cast thrown up in the normal course, is bound to restore appetite to any bird of prey, and is a signal that it will be up and on the hunt very soon afterwards.

And on such rare occasions I would wait with hopeful expectation, praying and watching, and feeling miserably cold inside for it would be just about sunrise on a cold winter's morning. I would wait only to see the peregrine fly off the perch after she had thrown her cast of feathers, and watch her go away into the distance rising higher and higher, continuously gaining height. The falcon I noticed would always be flying away from the sun, that is towards the west. I think this was done intentionally, as at such times when the falcon was seeking prey, had it been flying to the east, the sun directly in its eyes would have interfered with its spotting capability. Here the Song river flows in an east-west axis so the falcon would be coursing over the river bed all the time. Looking away from the sun gave me a better chance to follow her movements for a longer distance, but had she flown to the east squinting against the sun would have made it a blinding job to observe her progress.

It was most interesting to watch her manner of working, for she acted quite unlike other peregrines. Once the falcon had attained a certain height she would cease to climb any higher, but would simply continue to fly upriver for some distance by when the movement of some bird or the other directly below would attract her attention, invariably resulting in an almost vertical dive that would end in a certain kill. Immediately the falcon would triumphantly fly back to its perch on the river bed with the prey securely held in her claws. On the return trip to the perch the peregrine would fly it back just a few meters above ground level to shoot up to the perch when she got almost directly below the tree. She would settle half way up on a thick limb. Once comfortably perched she would start feathering the dead bird she had brought, and would shortly start eating it. A few crows would hang around in the vicinity, though strangely enough I never saw an eagle disturb her. In an area thickly infested with hawk-eagles, this struck me as odd. Once the meal over she would start preening her feathers. This would be the signal for me to leave for by now it would be almost eight in the morning, and time for my breakfast.

Sundays were observed as rest days on the farm, unless there happened to be some specially urgent work. On such days I would return to the peregrine's outpost immediately after breakfast to find her very contentedly sitting in the same place and on the same limb where I had left her almost an hour ago. At ten thirty or so she would be noticed rousing herself. After stretching her wings a couple of times and slicing a mute she would jump up to a higher branch, and from there to the topmost branch only to fly off downriver.

Twice I followed the peregrine as she flew into the distance, and on both occasions I surprised her at her ablutions. She would alight at some spot almost midway between the perch location and the confluence of the Song river with the Ganga. At this spot waters of the Song river had spread out over an immense area almost half a mile wide. There was a network of distributaries with the waters running only a few inches deep in some of the channels. Here and there lay scattered all over huge trunks of drift wood. It was a picturesque spot. Thickly wooded hills of Lansdowne Division lay in the east just across the Ganga. A few miles away and to the north beyond Rishikesh, rose the mighty Himalayas. In the south a spur of the Siwaliks could be seen sloping down to Hardwar, the gateway to Heaven for indeed as the old persian poet once said, "if heaven be on earth then it is this, it is this." At least that is how things stood some twenty years ago. It is changed now for the forests have been mostly cut in the immediate vicinity, there is very little wildlife left in the area, and even the hill tracts with their luxuriant growth of forests have begun to show bald spots in a lot of places. Here, and in such beautiful surroundings (beautiful in those days) the peregrine would be seen taking a bath. Bath over she would gingerly skip out of the shallow pool of water to perch on to some driftwood limb as it lay half buried in the river sands. Firmly gripping the perch in her claws, she would vigorously begin to flap her wings sending a fine spray of water scattering all around. After a few moments of this exercise she would stop flapping her wings to shift up and down the limb of the tree, every now and again turning and reversing her position as though she was about to select a spot to settle down for a photograph. With wings fanned out she would thus remain sitting for about twenty minutes when she would start preening her feathers. Through my binoculars I could easily see her feathers gradually drying in the sun. In a little while, a wet patch only would remain below her crop and she would at this stage fly off the driftwood perch. She never went to the dead tree by the railway bridge but would begin to soar till she became a mere speck floating against the velvet blue of the sky. A couple of times I caught her playfully making passes at kites but very soon, because of the colossal height she had gained she would disappear from my sight.

Her activities from then on till about four thirty in the evening, remained obscure. What she did or where she went was never known to me; however I would catch her surreptiously returning to her morning perch, the dead tree on the Song river, round about 4.30 and there she would remain till a few minutes before sunset. By that time a lot of bird traffic could be seen crossing the broad river bed. In this part the dry river bed stretched nearly a mile across. Flocks of parrakeets would be making for the sal forest on the other bank of the river. These would ofcourse be returning from the open cultivated patches where they had been feeding in the daytime.

The falcon would by now be scouring over the open area above, and directly over the river bed at a point where the parakeets crossed to fly into the sal forest which stood on the right bank of the Song river. Ultimately she would find one flock just below her winging its way to the roost. And then in that classical vertical dive of her's she would come down in the middle of the flock to grab a parrot and carry the protesting bird to her perch. Holding the illfated victim's neck in the barb of her beak, with one simple twist of her head the falcon would despatch its prey. This job is carried out by the entire falcon tribe very efficiently and in a most businesslike manner.

No time was lost in feathering the dead bird, and immediately afterwards she would settle down to tearing and devouring bits of the prey. It would be almost dark by the time the falcon finished her meal, and flew to roost in the same sal forest where the parrakeets had preceded her. This then was the pattern that each day repeated itself in the peregrine's activities from dawn to dusk. This peregrine on the river Song thus held me in thrall, like a talisman for nearly three weeks, till one fine morning she vanished from my life to fly to hunting grounds further south.

NOTES ON THE GREEN KEELBACK SNAKE (*MACROPISTHODON PLUMBICOLOR*)

THOMAS GAY[1]

INTRODUCTION

These notes were compiled from the observation of three different specimens, of which the first two came to me when young (8″ to 10″ in length and probably less than six months old). Snake A was taken on 28-9-69 and given away about one month later. Snake B was taken on 22-6-70; it escaped on 14-5-71 and was not recaptured. Snake C is still with me.[2] Taken on 29-5-71, it was at first thought to be identical with Snake B; however, certain differences of behaviour, and what seemed to be a lesser degree of intelligence, soon led me to conclude that it was a different individual.

Accommodation: While small, each snake was kept in a square glass jar 10″ high with a base of 5¼″ by 5¼″. The floor was covered with newspaper, and extra pieces of paper were kept for the snake to hide beneath. All pieces were changed as soon as found soiled. A small bowl of water was added. Snakes B and C, after some growth were kept in an observation cage 20″ by 12″ and 8½″ high, having a front of glass and a roof of fine wire mesh. Sheets of paper covered the floor, with some extra pieces scattered about. In one corner stood a bowl of water; in another rested an inverted piece of flower-pot, under which the snake slept or rested, tightly curled. The above "furniture" has been found entirely adequate for the comfort of this quiet and non-demanding reptile.

Description: So far as could be checked, the description given by Dr. P. J. Deoras in his SNAKES OF INDIA (pp. 112-113) was confirmed subject to the following details:—

(1) The thin lateral lines were whitish rather than yellow; with growth they disappeared.

(2) While the snakes were small, the ventral surface, with the exception of the white chin and throat, was definitely smoky black in colour; the surface turned ivory white only after several months of growth.

(3) The colour between the head chevron and nape chevron was lemon yellow, not orange. This colour fades with growth, and the chevrons become paler; at full growth the yellow has disappeared and scarcely a trace of the chevrons is left.

(4) The "black short cross-stripes across the body" were not observed.

(5) A few white spots (not mentioned by Deoras) are spaced at intervals along the back and flanks. These are ordinarily inconspicuous, but show up very distinctly when the body is distended after a meal. With growth the spots become pale blue rather than white.

(6) Snake C showed a small black spot on either side of the neck; the two did not lie exactly opposite to each other.

The grass-green colour is bright and shining (more in young than in old snakes) immediately after sloughing. The choice of

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[1] "Dev Kunj", Prabhat Road, Pune-411 004.

[2] These notes were written in 1974.

"plumbicolor" for the specific name is strange, being merited only for the last few days before sloughing, when the skin looks dull and grey.

Exact measurements were not easy to take, and were unfortunately neglected. Snake B was estimated by mid-December 1970 to have doubled its length of six months earlier; it had become markedly thicker and stronger during the six months of captivity. Its skins sloughed on 17-9-70, 6-10-70 and 29-10-70 were measured at 13″, 14″ and 15″ respectively. Such measurements no doubt have only a relative value, since a skin is liable to become stretched in length. Snake C's skin cast on 8-7-71 was measured at 22½″. Full growth was probably attained early in 1972, at an estimated age of two years. In September 1974 Snake C was measured at 24½″, its most recently cast skin measuring 26½ inches.

Snake B's body, after a heavy meal following a 26 days' fast (due to a temporary escape) was greatly distended; the green scales stood out like islands surrounded by blue-black, and the white spots were very prominent. For two days, sharp protuberances (presumably the frog's bones) could be distinctly seen along its flank.

The teeth consist of two short, sharp-pointed, triangular teeth in the upper jaw, placed one on either side, and of many small rudimentary teeth in the lower jaw. The latter serve only to grip the slippery prey; it is the two formidable upper-jaw teeth which inflict the wounds and draw the prey into the gullet.

General behaviour: Snakes A and B, and Snake C subject to the exception of rare occasions, were utterly gentle at all times and could be freely handled. While being handled, and at most other times also, the snakes moved sluggishly; only when hungry and in the immediate presence of prey did they execute swift and vigorous movements.

After completing a meal, the snakes would move about restlessly for some time and then retire to a place of concealment; here they would lie dormant until the need to defecate, to slough, or to feed again made them restless.

Snake C soon showed a tendency to anchor itself strongly by the tail; later, it developed the habit, when handled, of firmly gripping hand or finger with a half-coil. This snake showed much restlessness in August and September 71, but became very lethargic in the following January, probably due to the cold. Snake B had shown similar periods of torpidity in December (70) and February (71).

Snake C tended to become highly excited as soon as it was dropped into the feeding-jar, as though it knew that dinner was at hand. At such a time it would sometimes snap at a finger through the glass, open its mouth in a huge yawn of almost 180 degrees, and even try to bite the glass wall of the jar. This snake bit me on three occasions, and since such an experience has probably been shared by few people, it may be worth describing.

On the first occasion, which was the third day since the snake had come to me, I had just before handled frogs, and the smell may have acted as a provocation (although my observations tend to exclude the use of smell in detecting food). I began to pick the snake up in an altogether careless manner, and it immediately seized my right index finger and gripped with a power that surprised me. The two upper-jaw fangs pricked painfully and blood began to flow. The snake hung on like a bulldog, working his upper jaw on alternate sides (see the method described below). Quite apart from the pain, it was a strange sensation. I lifted the snake high in the air, but it hung on and continued to chew my finger. Then I had the idea of plunging both finger and snake into a bucket of water. Even thus submerged, the snake hung on for nearly one minute before I felt its grip slackening and it reluctantly allowed me to draw my finger away from its fangs. Blood was flowing freely, and my finger was smeared with a sort of saliva. There were several wounds on the upper surface of my finger, but none on the lower surface, where I had merely felt the woundless grip of the lower-jaw teeth.

I placed the snake inside the feeding-jar and gave it a frog, which it seized and swallowed at once. Despite having eaten four frogs in the preceding three days, it must have been still hungry. Next day, the snake allowed me to handle it without any hostile reaction, and it was many months before it bit me again.

On the second and third occasions, the snake was certainly very hungry and should have been handled with a caution that I had lost from over-familiarity. I tried the bucket-of-water treatment on the second occasion, but it took even longer than the first time. On the third occasion, being unwilling to endure the painful pricking longer than necessary, I cut the matter short by forcing the reptile's jaws apart by firm yet careful lateral pressure.

Skin sloughing: This took place almost always at night and therefore could not be observed. I did however see something of the process in the case of Snake A. On 15-10-69 it moved about restlessly all day, sometimes dipping into the water bowl. Peristaltic movements were observed, and after the skin had split at the head there were strong contractions and expansions of the mid-body.

The intervals at which Snake B sloughed ranged from 17 to 23 days during the monsoon, with an average of 20 days. They ranged from 32 to perhaps 38 days (the snake was at liberty from 15-11-70 to 7-12-70, during which time it must have cast at least one skin, though probably only one) during the winter, with an average of 37 days; and from 13 to 19 days ,with an average of 16 days, during the summer.

Snake C, before full growth, sloughed at intervals ranging from 23 to 26 days (average, 25) during the monsoon; and from 37 to 42 days (average, 39½) during the winter until observations were temporarily suspended. When observations were resumed, by which time the snake was fully grown, the recorded intervals were 21 days in the monsoon, 30 days between monsoon and winter, 41 to 47 days (average, 44) during the winter, 33 days between winter and summer, and from 20 to 25 days (average, 22½) during the summer and ensuing monsoon. These figures take no account of a wholly abnormal interval of 37 days between 3-7-74 and 9-8-74, for which I can give no explanation except the wild guess that the snake might have eaten a skin before I found it. The intervals of sloughing plainly follow a fairly regular curve from season to season, reaching a peak in about January.

In almost each case, the skin was whole and undamaged. I have been able to give many away to interested students and others.

Food and feeding: According to my observations the diet consists exclusively of live amphibians. No "small birds" (see Deoras) were offered, but worms and grubs were offered and refused even by a long-fasting snake. Dead frogs aroused no interest, and Snake B even abandoned a frog which it had itself killed by over-vigorous subduing. However, frogs which "shammed" death (as frogs sometimes do when exhausted and finally unsuccessful in all efforts to escape) were carefully examined and then seized.

The prey was seized, by a swift dart, at any available part of its body or limbs. When this happened to be the head, swallowing was easy and rapid, taking sometimes only a few seconds (6 seconds in the case of one small frog). If the first grip was on leg or waist, the snake would often, without allowing its victim to escape, gradually work round to the head. Sometimes a whole leg would be swallowed, followed by the trunk and the other limbs; sometimes a portion already swallowed would be disgorged in order to take a more convenient grip. An initially "awkward" grip, unless changed into a head grip, would entail a lengthy struggle to swallow lasting from 10 to 35 minutes. Where the frog was small relatively to the growth achieved by the snake, it could be confidently swallowed from the rear, all four legs being bunched up and disappearing last of all. A particularly strong and active frog might have to be subdued by vigorous chewing, in the course of which blood might flow and intestines leak forth. After being subdued, the frog would often be momentarily released and again seized by the head.

On 4-12-73 at 1945 hrs, Snake C was given a really large frog, larger than any attempted so far, and remarkable for abnormally well-developed thighs. The snake was very hungry and attacked the frog savagely at once. Four times it seized the frog, by hind leg, front leg, or waist; four times the frog escaped through its strength and vigorous kicking. A waist grip punctured the frog's body, allowing some blood and intestine to escape. Part of the snake's body became smeared with blood, and at one moment it began to seize its own blood-covered back. Its excitement reached such a pitch that once, when the frog tore itself free, the snake attacked the glass wall of the jar. Gradually the frog weakened, and the fifth grip, which was on the side of its head, seemed to suffocate it. When the fight had lasted some forty-five minutes, the frog, though still alive, appeared to give up. The snake now seized it deliberately by the head and began to swallow, which he found difficult owing to the victim's size, and his jaws were distended to an incredible extent.

Forty-five minutes later, the frog had been swallowed as far as his fat thighs, which, sticking out at right angles to the trunk, presented the snake with an insuperable difficulty. Twice the snake almost completely ejected the swallowed portion and tried afresh, but as I watched, I realised that it would never be able to complete the task unless one of the frog's thighs were removed. While I was cutting off one thigh, the snake retained the frog's head in its mouth, and when I had finished, it devoured the rest of the frog with little difficulty. The last toes disappeared at 2200 hours, just 2¼ hours from the time when the frog had been introduced into the jar. The snake's body was vastly swollen for most of its length, and twelve days elapsed before it was ready to feed again.

The method of drawing prey into the gullet is as follows:— One half of the amazingly flexible upper jaw, together with its pointed tooth, is raised clear of the frog's flesh, while the other half of the jaw keeps its tooth firmly embedded. The raised half is now advanced by a few millimetres and its tooth driven into the flesh. Now the hitherto "anchoring" half jaw is similarly raised, advanced, and driven into the frog slightly ahead of the tooth which is now "anchoring." Thus, by advancing either side alternately, the victim is gradually drawn into the snake.

The disappearance of the last limb is invariably followed by a prodigious yawn. The victim's body rapidly slips down the snake's body till it reaches the stomach. On one single occasion, a frog was ejected (by Snake B) in a semi-digested state on the day after it had been swallowed.

Once hunger had been satisfied, the snakes would ignore any additional frogs offered. A full meal would be followed by a fast, the length of which depended upon the quantity of food consumed, as well as upon the proximity of sloughing. Usually the snakes lost all appetite for up to a week before sloughing, and during such an interval Snake A even licked a frog's back without attempting to seize it; there were however instances in which food was taken on the very day previous to sloughing. Casting of a skin normally left the snake very hungry. Snake B once fasted for 25 days (11 before and 14 after a sloughing) even though food was offered; but this was a unique occurrence.

In the absence of any device for weighing the frogs, quantities of food were difficult to estimate. The best I have been able to do is to make an arbitrary allowance of 1 point for a "small" frog, 1½ for a "medium small", 2 for a "medium", 3 for a "medium large", and 4 for a "large". On this scale, Snake B consumed the following quantities of food in the shape of frogs:—

July (70)	6	
Aug.	5	
Sept.	7	
Oct.	9	
Nov.	5	(at liberty from
Dec.	14	15 Nov. to 7 Dec.)
Jan. (71)	9	
Feb.	4	
Mar.	12	
Apr.	5	(followed by a 25 days' fast from 16 Apr.)

It must be conceded that the division by months is yet another arbitrary feature.

On a similar reckoning, Snake C has consumed the following amounts for the periods during which observations have been recorded:—

Period A

June (71)	19	Oct.	16½
July	12	Nov.	7
Aug.	9½	Dec.	11
Sept.	12		

Period B (following a gap of 19 months)

Aug. (73)	10 (for half the month)	Mar.	13
Sept.	10	Apr.	12½
Oct.	10	May	16½
Nov.	16	June	11½
Dec.	8½	July	15½
Jan. (74)	11	Aug.	19
Feb.	7		

The average for both periods is the same: 12½.

The snakes — especially Snake C — could scarcely ever locate the frog in the feeding-jar until it jumped. In order that the method of capturing and swallowing might be observed, the snakes were fed, up to May 1974, inside a large glass jar, usually at night-time. It took me longer than it should have done to realise that the snakes may well have been partially dazzled by the electric light. After I began to feed Snake C in his living-cage, in darkness or at most a dim light, this snake was able to locate its prey more easily and quickly, and to perceive it at a distance of several inches. Scent appears to play no part in the locating; in the feeding-jar Snake C was often observed to "crouch", with his head above and almost resting on the frog, helplessly waiting for some movement to betray his prey's whereabouts.

Defecation was found to begin about 30 hours after the meal. The first defecation would be followed by one or two others extending up to the fourth or fifth day after eating. The faeces, consisting partly of a brittle white powder and partly of a viscous black paste, have a strong and objectionable odour.

Conclusion: I would definitely recommend the keeping of this species of reptile to all zoologists and others who have the capacity to be interested in animal life. *M. plumbicolor* is non-poisonous, attractive, readily handled, gentle when young at all times, and gentle when older at all times except when roused by considerable hunger. If handling is viewed with misgiving, it may be omitted altogether, although such an omission will naturally detract from the value of the experience to be obtained. After being provided with the simple accommodation and "furniture" described above, the snake requires no attention beyond the supply of live frogs from time to time, and the replacement of soiled paper.

Apart from the interest and pleasure which the snakes have given to me personally, I have found them a most useful aid in trying to make my fellow citizens aware of the folly (even "crime" is perhaps not too strong) of wantonly slaughtering at sight all snakes wherever met, the many innocent, beautiful and beneficial no less than the few dangerous or deadly.

POPULATION CHANGE OF THE HANUMAN LANGUR (*PRESBYTIS ENTELLUS*), 1961-1976, IN DHARWAR AREA, INDIA

YUKIMARU SUGIYAMA[1]
AND
M. D. PARTHASARATHY[2]

(*With a text-figure*)

The population density and the group composition of the Hanuman langurs (*Presbytis entellus*) was studied at Dharwar, South India, in 1976. For the purpose of comparison with 1961 study of the same population, the present research was carried out in the same season using the same methods as used in 1961. The population decreased to 54.5% during these 15 years. The social characteristics of the species, however, did not change. Most of the bisexual troops have only 15-16 animals, including one adult male, each. Many males live out of the troops and gather to form all-male parties. These characteristics are revealed to be maintained not only by the high population density but also because they are the very basic characteristics of this species in this area.

INTRODUCTION

For thirty days between June 17 and September 26, 1961, Sugiyama took a census of the Hanuman langurs (*Presbytis entellus*) in Dharwar area of South India. The langurs observed had parts of their home ranges covering Dharwar-Haliyal road and its sides between the points 3 and 30.6 km from Dharwar. The census revealed the population density, group size and group composition of the langurs in this area, and was followed by sociological studies, for nearly two years, of the same species (Sugiyama 1964). Parthasarathy participated, for several days, in this census, and for a year and a half for the later sociological studies. Most of the troops (bisexual troops), each of which consisted of about 15 animals, had only one full-grown adult male in addition to several adult females and immatures, occasionally having a few young or subadult males. Other than such bisexual troops, there were parties (all-male parties) with a loose social organization. Troops had small moving ranges; average for a troop in the forest was 16.8 hectares. These ranges were maintained throughout the study period of two years through antagonistic relationships among adjacent troops. All-male parties, on the other hand, had larger moving ranges and were living mainly in a comparatively poorer habitat with a few trees and a little food. They frequently split into several still smaller parties which rejoined to form all-male parties again. Whenever the members of an all-male party approached a troop, the male of the troop became extremely aggressive toward them and chased them out of his troop's range, showing much stronger aggressiveness toward them than toward adjacent troops (Sugiyama, Yoshiba & Parthasarathy 1965). But, sometimes the party males counterattacked the troop male, ousted him from the troop, took control of the females, and succeeded in taking over the

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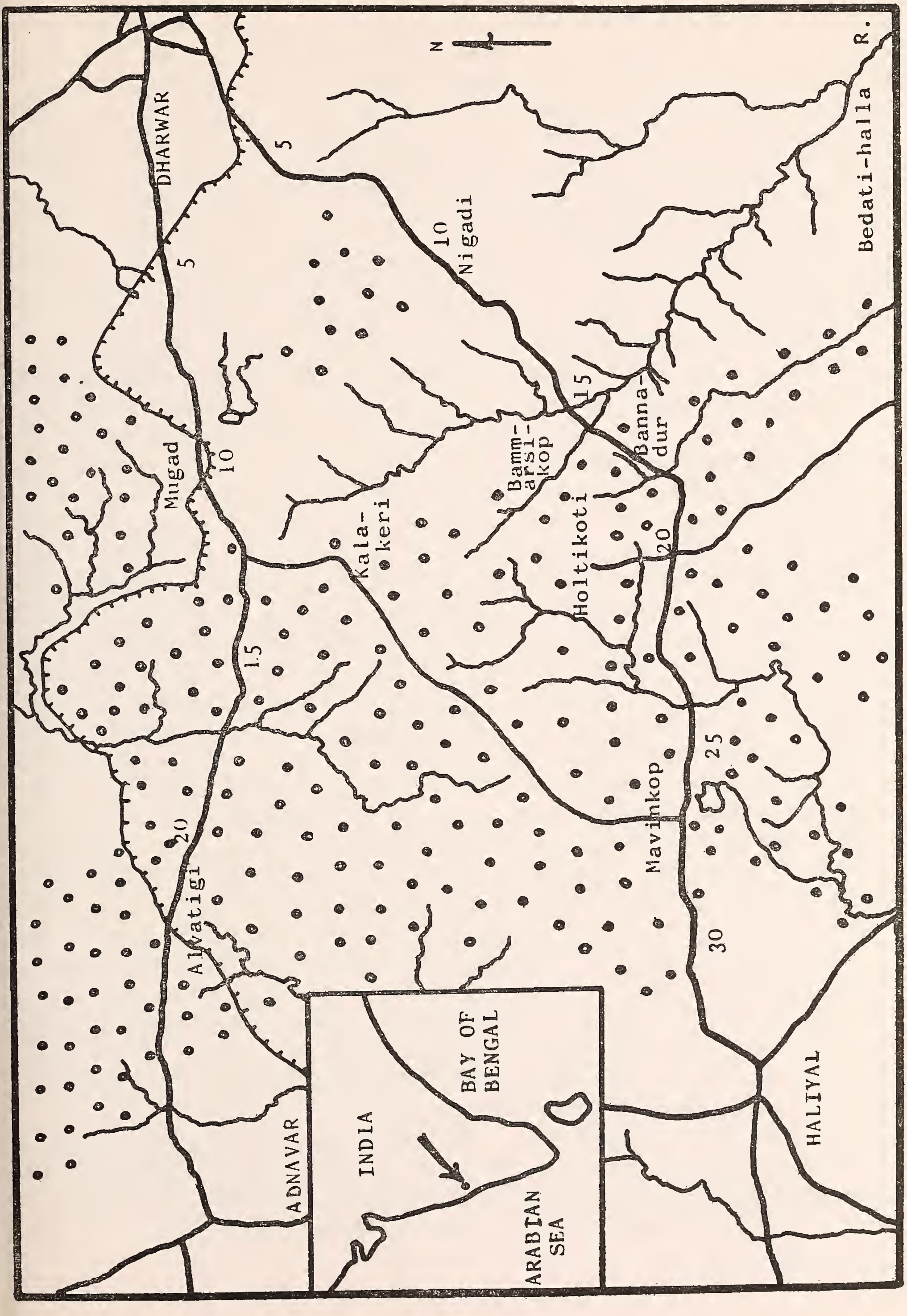
N
DHARWAR
5
5
Nigadi
10
Mugad
10
Kala-
keri
Bamm-
arsi-
kop
15
Banna-
dur
Holtikoti
20
15
Mavinkop
25
20
Alnavatigi
30
Bedati-halla R.
ADNAVAR
HALIYAL
INDIA
BAY OF BENGAL
ARABIAN SEA

▬ = road 〰 = stream ┬┬┬ = railway road ●● = forest

Fig. 1. Map of Dharwar. The forest part is shown by the small circles and the number under the road is the distance from Dharwar in kilometre.

moving range of the troop chasing out all the subadult and juvenile males and killing all the infants. Dispute followed even among party males and, as a result, only one male remained in the troop which had been taken over. Thus, finally, the typical one-male troop organization resulted. Troop males including subadults and the juveniles, who were ousted from the troop, might have joined a party or formed a party of themselves (Sugiyama 1965, 1966, 1976). Repeatedly undergoing this kind of social change, the particular type of social organization of the Hanuman langurs of Dharwar can be expected to be maintained for many years.

Mohnot (1971), Parthasarathy & Rahman (1974), Hrdy (1974, 1977), Ripley (personal communication) and the others confirmed a similar process of social change in different populations of this species living in different habitats of the Indian subcontinent and Sri Lanka (Ceylon). But there had been no evidence to confirm the fact that the maintaining mechanism of this particular type of one-male troop organization was not a temporary survival strategy in an especially severe environment and, thus, a confirmation of this hypothesis, by studying the same population of langurs some years after the first census was of utmost importance. To meet this objective, another census after a lapse of 15 years was taken.

STUDY PERIOD AND METHOD

The authors conducted the present census to estimate the population of the Hanuman langur in August 1976 using almost the same methods as used in 1961. They searched for langurs in areas extending upto 20 m on either side of Dharwar-Haliyal road between the points 3 and 29 km from Dharwar (Fig. 1). The data was collected by driving slowly repeatedly on the same section, in a three-wheel motor-cycle for 14 days from August 4 to 19. The census in 1961 had been taken between the points 3 and 30.6 km from Dharwar. But since the forest beyond the point 29 km from Dharwar had been changed into cultivated fields after 1961, the present census had to be terminated there. For the purpose of comparison with 1976 census, only the data between the points 3 and 29 km, of 1961 census will be presented in this article.

The total time of 30 days required for 1961 census was shortened to 14 days for the present study. One reason for doing so was that all the groups which had parts of their home ranges along the sides of the road could be confirmed much earlier in 1976 than in 1961, when all the groups were confirmed before the 20th day of observations. Secondly, the efficiency of searching for langurs was much greater in 1976 than in 1961. This is because in 1961 Sugiyama alone had to search for langurs, driving a jeep or a motorcycle by himself, whereas in 1976 both the present authors as well as the driver of the three-wheeler searched for the langurs. Moreover, the authors were more familiar with the area and had more research experience in 1976. Consequently, they were convinced that almost all the groups of langurs which had their moving ranges in the area under study had been recorded as precisely as in 1961 census (In 1961 and 1962 an intensive study in the sample area, following the census, revealed that 95% of the langurs who had their moving ranges on or along the road had been recorded during the census period).

The identification of the groups was done by the group size, its age-sex composition, and by identifying some characteristics typical of certain individuals in the group.

TABLE 1

GROUP DISTRIBUTION OF HANUMAN LANGURS AT DHARWAR

	1961 Census						1976 Census									
Distance from Dharwar	Field Condition	Troop or Party	Group Size	Adult ♂	Adult ♀	Juvenile and Infant	Troop or Party	Group Size	Full Ad- ♂	Just Ad- ♂	Full Ad- ♀	Just Ad- ♀	Senior Juvenile	Junior Juvenile	Infant (New Baby)	Remarks
3 km	Openland (Cultivated Field or Grassland)	T	10	1	6	3										
4		T	9	1	2	6										
5																
6		T	11	1	5	5										
7		P	9	6		3										
8		T	12	1	8	3										
9							T	2			1		1			Main part of Troop 1 was not found
10		T	17	1	9	7	T	10	1		6	2	1			
11		T	19	1	13	5	T	12	1		6	2	2		1	
12		T	21	5	8	8	T	26	1		13	2	4	4	2	
		P	10	8		2										
13		T	21	1	14	6										
14		T	19	1	9	9										
15		T	9	1	7	1										
		P	7	7			T	8	1		3	1	1		2(1)	
16		T	18	2	10	6	T	14	1		6	1	1	2	3	
17	Forest	T	23	1	10	12	T	16	1		8	1	2	2	2	
		T	22	6	7	9	T	27	1		12	1	4	4	5	
18		T	12	2	8	2	T	15	1		8	1	2	3		
		P	11	11			T	30	1		13	1	5	4	6	
19		T	11	2	6	3	T	17	1		6	1	4	3	2	
		T	16	1	8	7										
20		T	13	5	4	4	T	14	1		6	1	1	2	3	
		T	21	1	11	9	T	32	1		14	1	7	5	4	
		T	23	1	13	9	T	13	1		5		4	1	2(1)	
		T	20	1	8	11										
21		P	32	24		8	T	5			2	1	1	1		No ♂ of Troop
		T	12	1	6	5	P	15	7	3			2(♂)3(♂) . .			15 was found*
		T	24	3	11	10										All ♂ Party A*
22		T	16	1	13	2	T	14	1		7		1		5	
		T	12	1	6	5										
		P	2	2												

	T	11	1	9	1										
23	T	12	1	7	4	T	16	1		8		1	2	4	
	T	11	1	5	5										
	T	17	7	6	4	T	11	1	1	5	4				
24	T	9	1	6	2	T	6		1	2	1	1		1....	No ♂ of Troop 19 was found*
	T	10	1	7	2										
25	T	10	1	7	2	P	7	6	1				.....	.....	All ♂ Party B*
	T	11	2	9		T	17	1	1	8	1	2	2	2	
26	T	19	4	9	6										
	T	11	1	6	4										
27															
28	T	11	1	5	5										
	T	15	1	7	7										
29	T	17	1	9	7										
Total		626	123	294	209		327	30	7	139	22	47	38	44(2)	

* Troop 15 and ♂ Party A, Troop 19 and ♂ Party B were sometimes found together.

CHANGES IN THE ENVIRONMENT

Though during these 15 years the cultivation extended slightly into the forest, yet the forest/openland ratio did not change much, at least between the points 3 and 29 km from Dharwar. Whole of the forest was covered with secondary dry deciduous forest dominated by planted teak (*Tectona grandis*). Trees in many parts of the forest had been cut and replanted and, at the same time, many new forests had appeared at the other parts. A whole deforestation did not proceed during the 15 years. For example, the northern part of the intensive study area of 1961-1963, between the points 21.5 and 23 km from Dharwar, was rather a matured teak forest and the southern part was an open scrub-forest about 2 years old after plantation (Sugiyama, Yoshiba and Parthasarathy 1965). The former was cut in 1965 or so, replanted, and was a young matured forest in 1976. The latter, on the other hand, was fully matured in 1976.

Significant change that could be noticed after 15 years was that the plantation of teak was being gradually replaced by that of eucalyptus (*Eucalyptus* sp.) which was not seen in 1961. Many small patches of eucalyptus trees could be seen in the census area in 1976. Teak flowers and young leaves were eaten by the langurs who also used teak trees for resting and sleeping. Rarely were they seen in eucalyptus trees.

RESULTS

During 1961 census 7.5 groups a day, on an average, had been discovered and the maximum number of groups discovered in a single day was 14. But in 1976 only 4.8 groups a day, on an average, were discovered and the maximum number of groups identified in a single day was 9. The total number of the groups

TABLE 2

COMPARATIVE DATA OF 1961 AND 1976 POPULATION CENSUS OF THE HANUMAN LANGURS ALONG DHARWAR-HALIYAL ROAD, BETWEEN THE POINTS 3 AND 29 KM FROM DHARWAR

	1961	1976	remarks
No. of Groups discovered per day	7.5	4.8	
Maximum No. of Groups discovered in a day	14	9	
No. of Groups living (Troops-Parties)*	43 (37-6)	22 (20-2)	
No. of langurs living (Troops-Parties)	626 (55-71)	327+x(305+x-22)	x is main part of Troop 1
No. of adult ♂ (Troops-Parties)	123 (58-65)	37 (20-17)	
No. of adult ♀	294	161	
Ad♂/Ad♀ ratio (Troop)	0.42 (0.20)	0.23 (0.13)	excluding Troop 1 (1976)
Mean Troop Size (Ad♂-Ad♀-Immatures)	15.0 (1.6-7.9-5.3)	16.0 (1.1-8.4-6.7)	excluding Troop 1 (1976)
Mean Party Size	11.8	11	
Roadside Density (Openland-Forest)	24.1 (13.4-34.8) head/km	13.1 (5.5-20.7) head/km	x of Troop 1 is calculated to be 14

* Troop = bisexual troop Party = all-male party

seen as many as 67 times during the census period of 1976 was confirmed to be 22 with 327 langurs. This is slightly more than half of 43 groups and 626 langurs confirmed in 1961 census.

The distribution, size and the age-sex composition of each group are shown in Table 1 and the comparative data of 1961 and 1976 census are shown in Table 2.

From August 13 to 15, at a point 9 km from Dharwar, an adult female and a senior juvenile were found in a tree. They did not move throughout these 3 days and kept looking in a certain direction. Since their behaviour was similar to that of typical stray animals, they were assumed to be a part of a troop, and were waiting in their familiar tree to join the main part of the troop that could never be traced during the census period. These two langurs were recorded as belonging to Troop 1 which has been excluded from certain data processings for this article.

No males were found in Troops 15 and 19. Also the numbers of adult females in these troops were extremely small. Due to the fact that these females were, sometimes, found mixing with all-male parties, they were taken as parts of two different bisexual troops from which adult males had already been ousted by all-male parties and, consequently, the females of the troops were scattering away or moving with the males who had been ousted. Although the exact evidence of social change could not be found, they have been treated as two different troops.

All the troops except Troops 1, 15 and 19 were typical one-male troops, each with only one full-grown adult male. The number of adult males, including young adult males, per troops was 1.1 (Troops 15 and 19 included). This number is certainly smaller than that of 1961 census i.e., 1.6 males per troop. This means that "the matured troops" i.e., troops with more than one male each, were fewer in 1976 than in 1961. The same is true for party males. The average size and age-sex composition of a troop, however, did not differ much in the two studies. Population density, on the other hand, showed a considerable decrease; 41.4% in the openland (considering the unknown part of Troop 1 consisting of 14 animals) and 63% in the forest. In 1961, groups of langurs between the points 3 and 9 km from Dharwar and again between the points 12.5 and 15.5 km from Dharwar were frequently observed but in 1976 neither the langurs themselves nor the signs of their activity could be traced.

Discussion and conclusion

A. **Population Density**

It may be felt that the decrease in the population density of the Hanuman langurs, as shown by 1976 census, may be due to the short period during which the census was taken. But from the fact that in 1976 the authors used more efficient methods and that even then the average number of groups discovered in a day was only 64% of the average for a day in 1961 (refer Table 2), it can be said that the population density of langurs in 1976 was even lesser than 64% of that in 1961.

What reason can be attributed to this decrease? Increase of cultivated fields and the decrease of forest were not so large, at least between points 3 and 29 km from Dharwar. Therefore, the deforestation may not have had much significant effect on the population density. But replacement of teak plantations by eucalyptus may effect the environmental value for the langurs. This problem was not very serious at the time of the present study though it may become severe in the near future. Although no exact information on the trapping of langurs in Dharwar area could be obtained, there were reports that the activity of monkey catchers had increased tremendously throughout India during the 15 years and, thus, it is possible that even in Dharwar area some langurs had been captured. Even if the actual trapping of the langurs was little, the significant decrease i.e., 41.4%, of langur population in the cultivated fields (openland) shows an increased human impact on langurs as being responsible for this decrease. Despite the fact that there has not been much deforestation throwing of stones by villagers and attacks by domestic dogs has lowered the environmental value for the langurs and, consequently, their population density.

Siddiqi & Southwick (1977) found that a sample population of rhesus monkeys (*Macaca mulatta*) in Aligarh District of North India, declined to 51% during 12 years from 1962 to 1974. They emphasize that the main reason for this decline have been the increasing view of monkeys as agricultural pests, the loss of traditional protection given to rhesus monkeys by most of the people, the loss of jungle habitat through more intensive agriculture, and the commercial trapping of rhesus for export. Most of these reasons, except the last one, can be said responsible for the decrease of population density of langurs of Dharwar.

It is quite possible that further urbanization, increasing human population density and the transport facilities, and controlled plantations into eucalyptus will further push down the population density of langurs in Dharwar as well as in other districts of the country.

B. Social Organisation

Although the langur population density had decreased to 54.5% (considering the unknown part of Troop 1 consisting of 14 animals) during the 15 years, the fact that the size of the troop, its age-sex composition and the frequency of the all-male party, and especially the one-male troop organization did not change should be emphasized. Sugiyama (1967) hypothesized that the maintaining mechanism of the particular one-male troop organization of the Hanuman langur over a long period has an adaptive value in controlling the population density as well as in maintaining the basic characteristic of this species. The 1976 census revealed that a decrease in the population density, even by one half, cannot change the frequency of rejuvenation of the troop and that this particular organization is a very basic characteristic of the Hanuman langur.

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THE NANDA DEVI SANCTUARY—1977

Lavkumar Khacher[1]

(*With a plate and three maps*)

INTRODUCTION

The Nanda Devi Basin, situated in the Gharwal Himalayas, is also known as the Nanda Devi "Sanctuary" to mountaineers by virtue of its almost inaccessible terrain which kept the mountain inviolable till 1934, when Shipton and Tilman pioneered a trail up the Rishi gorge to reach the base of the mountain. In doing so, they were the first men to ever put foot into a remarkable mountain basin with rich pastures and a veritable Garden of Eden where herds of Himalayan ungulates grazed which knew no fear of man. The "Sanctuary" referred to in this report means the Nanda Devi Basin.

DESCRIPTION OF THE STUDY AREA

Location: The Nanda Devi "Sanctuary" is situated in the Gharwal Himalayas in the upper watershed of the Alakananda, the eastern arm of the R. Ganga. It lies within the co-ordinates 30°16′N to 30°32′N and 79°44′E to 80°02′E. The 799 sq kms mountain basin falls within the jurisdiction of the Chamoli District of the Uttarakhand Division of Uttar Pradesh (U.P.). The eastern and southern rims of the basin form the border of Chamoli District with Pithoragar District and Almora District respectively.

The Mountain Barriers: The "Sanctuary" is demarcated by a high enclosing mountain range offering icefalls and corniced ridges to the outer world. Only in the northwest is there easy access for a short period from the last week of May till October. The Rishi Gorge, as will be explained later, is difficult of access. The mountain rim has on it such major mountains as Dunagiri 7066m., Changabang 6864m., Kalanka 6931m., Rishi Pahar 6992m., Nanda Devi East 7434m., Nanda Khat 6611 m., Mrigthuni 6855m., Trisul 7120m., and Bethartoli Himal 6352m. Nanda Devi 7816m., India's second highest mountain, is situated on a short ridge projecting from the eastern rim joining the main summit with Nanda Devi East. A sharp hog's-back ridge from Dunagiri culminating in the 3848m. high Lata peak and a rugged, glacier-scarred ridge from Bethartoli converge onto the western end of the Rishi Gorge, compressing the river in a narrow, sheer-sided gorge. Entry into the basin is over the Lata ridge at the Dharasi Col (4250m., a short distance up the ridge above Lata peak. (Sketch Map 1).

The Nanda Devi Basin or "Sanctuary": The "Sanctuary itself is a vast glacial basin segmented by a series of parallel ridges with a north-south trend, emanating from the encircling mountain ramparts. The most important is the Devistan-Rishikot ridge, which separates the Inner "Sanctuary" at the base of Nanda Devi from the rest of the basin—the Outer "Sanctuary". The Malthuni Ridge between Dharasi and Dibrughetta is a short but very prominent ridge from the northern range and its magnificent cliffs drop into the Rishi Gorge opposite equally magnificent cliffs terminating a jagged spur from the Bethartoli Himal.

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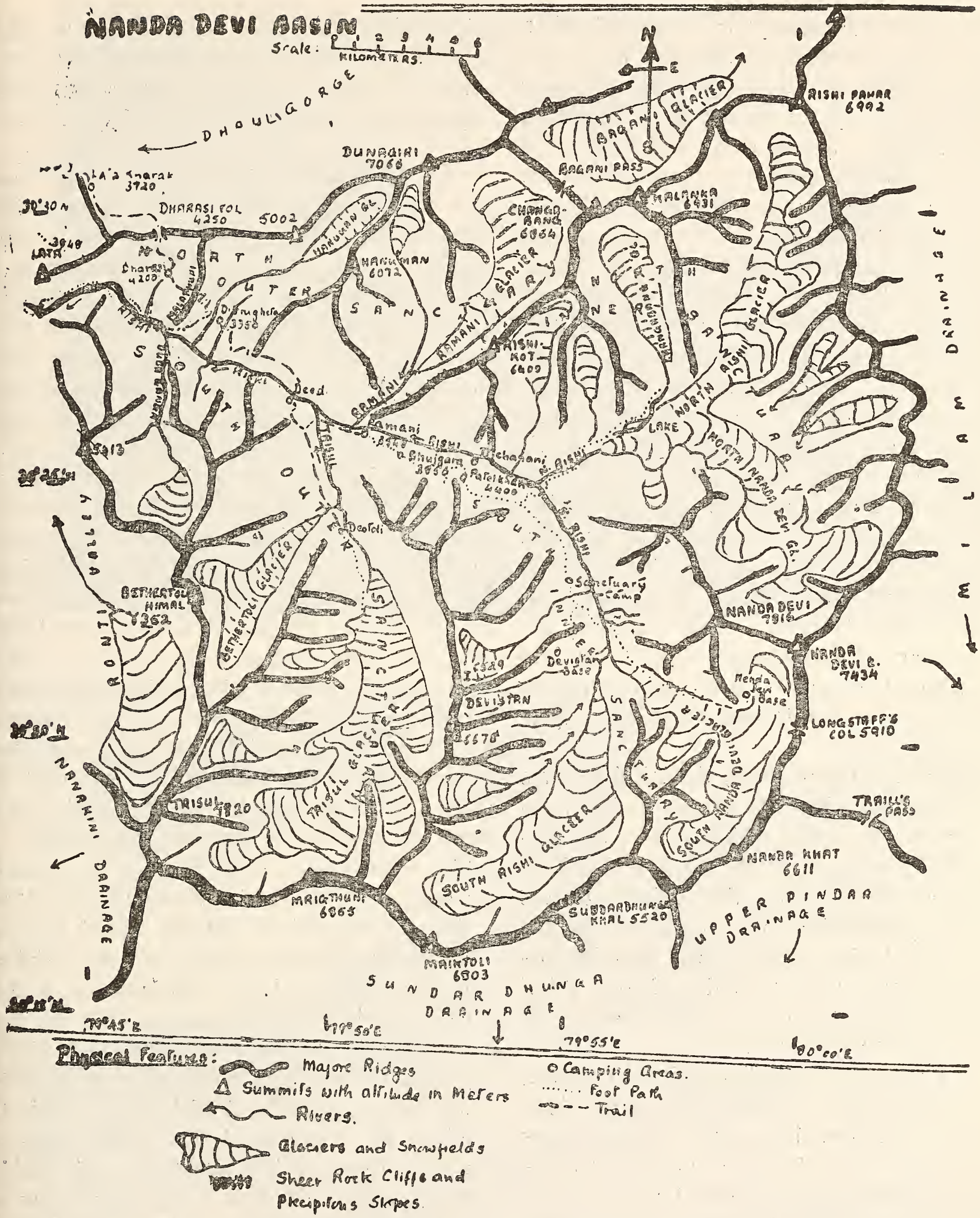
[1] 14, Jayant Society, Rajkot-360 004.


NANDA DEVI BASIN
Scale: 0 1 2 3 4 5 6 KILOMETERS
N
E
DHOULI GORGE
DUNAGIRI 7066
BAGANI GLACIER
BAGANI PASS
RISHI PAHAR 6992
Lata Kharak 3720
30°30'N
DHARASI COL 4250
5002
3940 LATA
Dharasi 4200
NORTH OUTER SANCTUARY
HANUMAN GL.
HANUMAN 6072
CHANGABANG 6864
CHANGABANG GLACIER
KALANKA 6931
RISHI
Dibrugheta 3350
SOUTH OUTER SANCTUARY
Hitkri
Deodi
RAMANI
RAMANI GLACIER
RISHI KOT 6409
NORTH INNER SANCTUARY
NORTH RISHI GLACIER
LAKE
NORTH NANDA DEVI GL.
Ramani 3353
Bhujgara 3650
Patalkhan 4400
Tilchanani
N. RISHI
S. RISHI
TRISUL
Deodi
5313
30°25'N
RONTI VALLEY
BETHARTOLI GLACIER
BETHARTOLI HIMAL 6352
Sanctuary Camp
SOUTH INNER SANCTUARY
NANDA DEVI 7816
NANDA DEVI E. 7434
Devistan Base
5529
DEVISTAN 6678
Nanda Devi Base
SOUTH INNER SANCTUARY
NANDA DEVI GLACIER
LONGSTAFF'S COL 5910
MILAM DRAINAGE
30°20'N
NANDAKINI DRAINAGE
TRISUL 7120
TRISUL GLACIER
SOUTH RISHI GLACIER
SOUTH NANDA DEVI GL.
TRAILL'S PASS
NANDA KHAT 6611
MRIGTHUNI 6855
SUNDARDHUNGA KHAL 5520
UPPER PINDAR DRAINAGE
MAIKTOLI 6803
SUNDAR DHUNGA DRAINAGE
30°15'N
79°45'E
79°50'E
79°55'E
80°00'E
Physical Features:
Major Ridges
Summits with altitude in Meters
Rivers.
Glaciers and Snowfields
Sheer Rock Cliffs and Precipitous Slopes
Camping Areas.
Foot Path
Trail

Map 1. Nanda Devi Basin: Physical features.

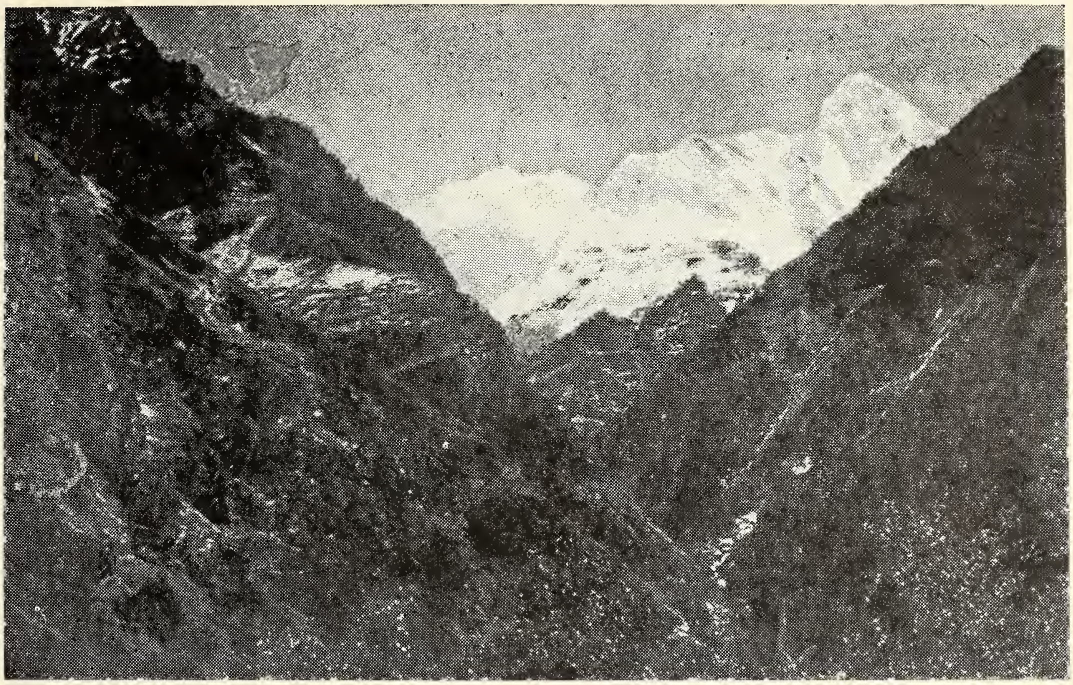
The Inner "Sanctuary' is composed of a glacier system divisible into the North Inner "Sanctuary" and the South Inner "Sanctuary" by the Nanda Devi mountain. The northern system is by and large at a lower altitude with a bigger area. There are three large glaciers: the Nanda Devi North, the Rishi North and the Changabang glaciers. The southern system has the Nanda Devi South and the Rishi South glaciers. The southern glaciers are more active than their northern counterparts, though, like all Himalayan glaciers, they have been retreating and their lower stretches are collapsed heaps of rubble and glacial debris with the laterial morains forming high, distinctive ridges above the subsiding glaciers. Each system gives rise to ablation streams, the North Rishi and the South Rishi which flow along the precipitous cliffs of Nanda Devi. A short distance below their confluence, the Rishi flows into its stupendous upper gorge, cutting at right angles across the Devistan-Rishikot ridge.

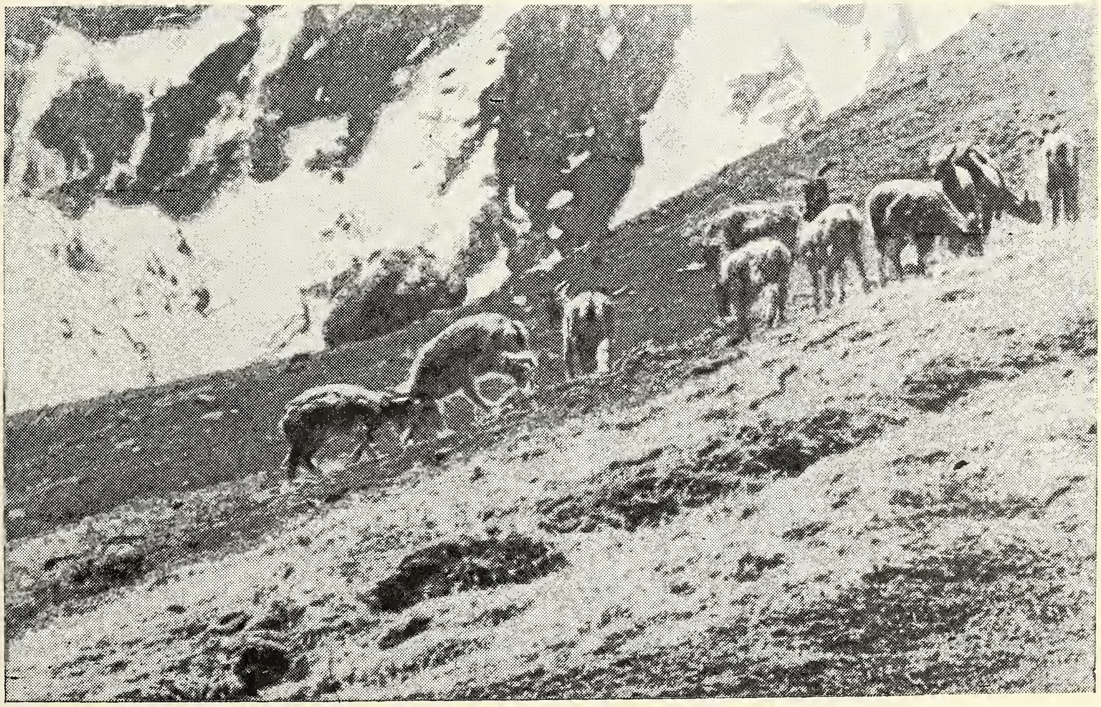
Clearing the upper gorge, the Rishi receives the tumultuous Ramani stream, racing down a precipitous gorge which drains the Ramani glacier basin on the north and a little further downstream, the Trisul torrent joins the Rishi from the south, draining the extensive basins of the Trisul and Bethartoli glaciers. The Ramani and the Trisul glacier systems form important features of the Outer "Sanctuary".

The Rishi stream continues along its chasm receiving various torrents from both sides, some by narrow impassable gorges, others as graceful waterfalls, to finally enter the awesome lower gorge guarded by overhanging cliffs, and skirt the Lata peak to merge with the Dhauli Ganga near Reni Village. The Rishi Gorge cuts all the ridges at right angles, and is therefore difficult to negotiate. Except for this narrow, steep-sided gorge, the entire basin is well above 3500m.

The Surrounding Valleys: The northern wall from Lata to Rishi Pahar is the divide between the Nanda Devi Basin and the Dhauli Ganga. Of the several ravines and glaciers scarring the northern face, the Bagani Glacier, drained by the lovely Dunagiri valley, is the most significant. The eastern wall from Rishi Pahar to the bifurcation of the Traill's Pass ridge runs parallel to the great Milam glacier. Several side glaciers carry the snow and ice into the main Milam glacier. The southern ridge from the Traill's Pass bifurcation to Trisul II overlooks the warm foothills to the south and offers an unbroken barrier to the warm moist winds. The heavy precipitation on this face drains by several valleys, the Sundardhunga Valley being the most significant, into the Pindar which is a major tributary of the Alakananda. The western rim, formed by Trisul and Bethartoli Himal, also receives heavy precipitation on its western face, and is drained by the Nandakini and Birahi Ganga Rivers into the Alakananda.

The Rishi Ganga itself, through the Dhauli Ganga, with the major rivers like the Pindar, the Nandakini and the Birahi Ganga, forms an important part of the Alakananda's watershed. The Alakananda is the eastern twin of the Bhagirathi. The two join to form the Ganga, the waters of which govern the destinies of the millions inhabiting the Ganga plain. A high dam is projected on the Ganga, and one of the considerations foremost in context with this ambitious project will always concern the quantity of silt brought down by the turbulent rivers. The erosion of the Nanda Devi Basin





Above : A view of Nanda Devi. *Below* : Bharal in Nanda Devi basin.
(Photos : *Author*)

will have to be taken into account. People of the area are fully aware of the disastrous floods caused by deforestation of the mountain slopes, having experienced such major disasters as the Ghona Tal flood in the last century and the Alakananda flash floods of 1970.

CLIMATE OF THE NANDA DEVI "SANCTUARY"

The Nanda Devi complex is situated at the turning point where the Himalayan chain changes its N.W. to S.E. trend to a west to east trend and the entire southern mountain-wall with its extensions to the west and east along the Trisul II Jatropani ridge and the Nandakot range beyond the Traill's Pass respectively exposes a continuous southern aspect to the lower foothills and the sun. These slopes, as also the western watershed ridge of Trisul and Berthartoli and its westward bifurcation of Nanda Ghunti, cause considerable updrafts of warm air throughout the year, resulting in high precipitation and heavy cloud cover. During the rainy season these ranges receive the full blast of the S.W. Monsoon and rainfall is extremely heavy. The monsoon effect starts being felt in the third week of June and from within the "Sanctuary" we daily witnessed fantastically tumultuous cloud formations over the mountain walls on our south and west, with spectacular displays of lightning. We concluded that the Pindar, Nandakini and Birahi Ganga Rivers between them must contribute a very large proportion of the Alakananda waters.

The eastern mountain divide had daily cloud build-ups, but these were far less spectacular than along the southern wall, a fact which is explained by the drier climate of the Milam area, lying as it does beyond the main Himalayan range. The same was true of the northern wall, though Dunagiri dominating the Dhauli gorge pulls up considerable warm air. Its influence creates the late afternoon cloud and mist on the Lata ridge and the Dharasi Col. The snow conditions, with thick snow cornices overhanging the southern ridge and the more active glaciers like the Nanda Devi South, the Rishi South and the Trisul Glaciers, suggest heavier snowfalls on the southern side. Our observations during the expedition and photographs of the outer side of the "Sanctuary" substantiate our conclusions. Among its other unique qualities the "Sanctuary", by virtue of its configuration, enjoys a sub-climate of its own. There is obviously a mass of cold air on the basin which, as our preliminary and amateurish observations revealed, exerts a significantly powerful effect on the precipitation of the Almora and Chamoli Districts.

The cold air on the basin creates a dry climate with low annual precipitation. Inside the "Sanctuary", the snowline was well above 4500 m. as against the heavy winter snow on the Dharasi Col and the Malthuni ridge considerably below this altitude. Snow was thicker and generally at a lower altitude on the southern side of the "Sancutary" than the northern, which conforms to the general conditions on the south and north aspects of mountains in the northern hemisphere. The entire northern side of the "Sanctuary" receives more direct sun rays and is consequently warmer, with more rapid thawing of snow.

While the glacial basins and upper slopes experience strong diurnal winds, the gorge itself, unlike other major Himalayan valleys, is very sheltered. This surprised us till we were able to watch the cloud movements from higher slopes and saw how flanking ridges diverted the air currents up their sides. The Malthuni and the Rishikot ridges dramatically demonstrated their influence on the warm air blowing into the gorge. While strong winds were a regular feature on the higher slopes from a couple of hours after sunset almost to sundown, the nights were invariably calm. The diurnal winds produced clouds in the afternoon and there was usually a light drizzle or sleet towards the evening. Twice in the last week of May we had light snow all over the "Sanctuary", and there was widespread snowfall as late as on 17th June. The snow, however, rapidly melted. With the onset of the monsoon stream in the third week of June, there was considerable inflow of warm air up the gorge resulting in light mist over the high meadows and this warm air had a profound effect on the wintery conditions which lingered on late into summer. Under its influence, the winter snow rapidly melted. While considerably curtailing the hours of insolation, the mists and low clouds in June kept the soil moist—a factor not found in the drier inner Himalayan valleys or on the Tibetan Plateau. Thus, the Nanda Devi "Sanctuary", though receiving little precipitation, supports a lusher vegetation than other secluded valleys.

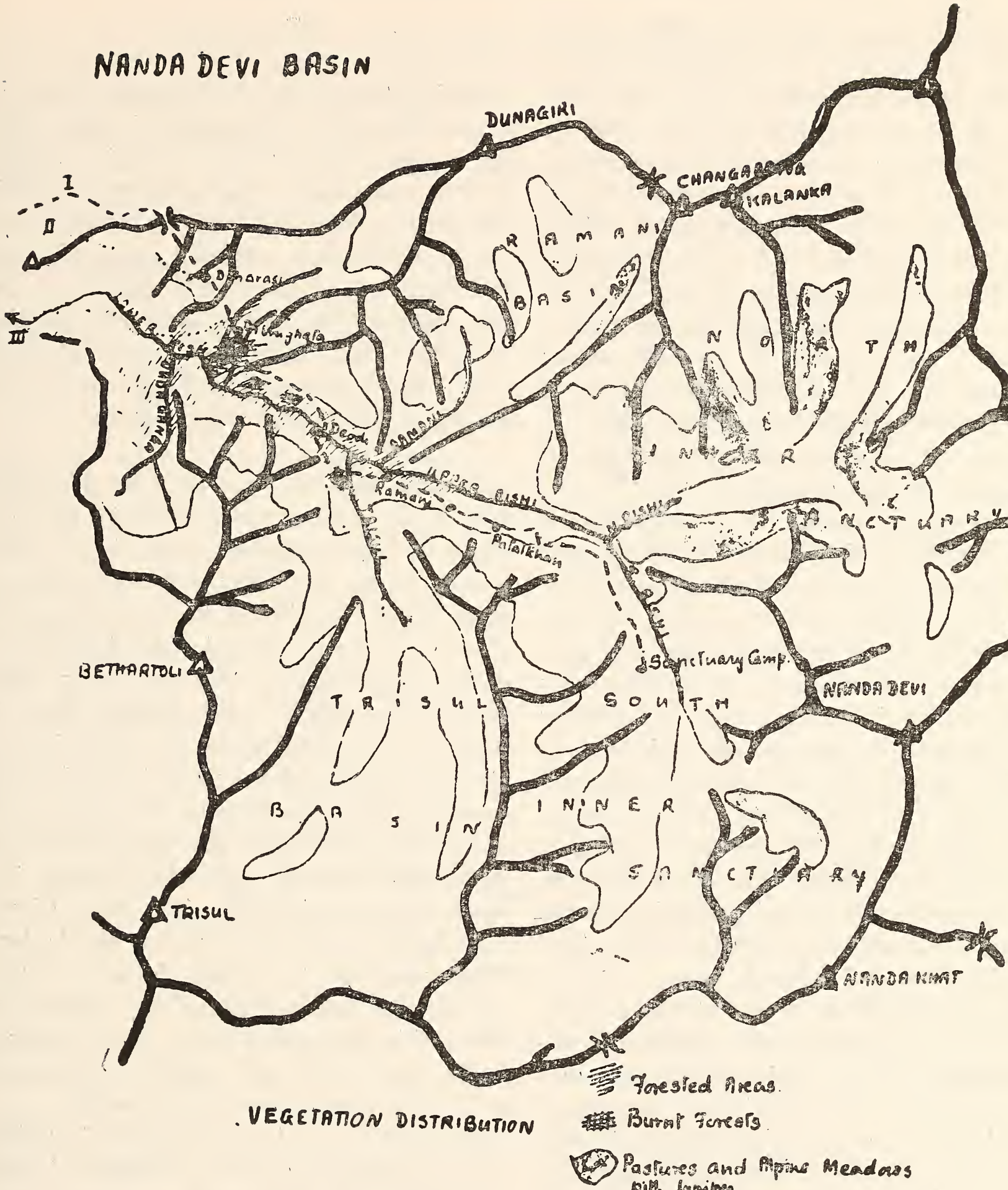
A very distinctive feature of the weather around Nanda Devi is the fact that unlike other major Himalayan peaks, the great mountain has very little cloud formation on it in the afternoons. Even in June and July when the monsoon stream was well set in the area, and while expeditions had withdrawn from lower peaks like Trisul, it was possible to operate on Nanda Devi a full fortnight later. On most days, when clouds obscured all the other summits around, they formed only around the great peak's base and on the very summit itself. This advantage of a longer operative season on Nanda Devi offers significant advantages to be borne in mind if any control of expedition activity is planned. The fact that the day Tilman ascended the mountain in 1936, the Almora area received exceptionally heavy rainfall is worth recording here.

THE FLORA

The vegetation of any region reflects the climate prevailing there and the distinctive climate enjoyed by the Nanda Devi complex has created a distinctive flora which, though it superficially brings to mind the other inner Himalayan valleys, suggests to a more careful observer considerable variations. A very thorough investigation would most certainly highlight the unique composition of the "Sanctuary's" floral community. (See Map 2).

Forest forms a very small percentage of the flora of the "Sanctuary" and is restricted to the Rishi gorge. The largest stands of coniferous forests grow in the Ronti valley (not within the limits of the study area) which is open to moisture-bearing winds from the lower Dhauli Gorge, the Dudh Ganga valley within the basin and the Dibrughatta glade. The dominant conifer is the Himalayan Fir *Abies pindrow*. Significantly, there were no Spruce *Picea morinda* anywhere along the trail. Though there is a fine stand of Deodars *Cedrus deodara* at Lata, this lovely tree was absent inside the "Sanctuary". The conifers have an admixture of tree rhododendron *Rhododendron arboratum* and both the pink and white varieties of wild rose *Rosa* sp. In May, the forests looked very dry, suggesting light winter snow and little or no spring showers. The soil was exceptionally light and powdery as a result.

Above the conifers, and forming a broad belt between them and the high altitude meadows, were fine forests of Birch *Betula utilis,* largely leafless in May but under full foliage in late June. These forests are a characteristic aspect of the trail from Dibrughetta to Ramani.


NANDA DEVI BASIN
DUNAGIRI
CHANGABANG
KALANKA
RAMANI
BASIN
NORTH
INNER
SANCTUARY
Dharasi
Tilchaunghala
RISHI
Deodi
RAMANI
UPPER RISHI
Ramani
Patalkhan
RISHI
Sanctuary Camp.
NANDA DEVI
BETHARTOLI
TRISUL
BASIN
SOUTH
INNER
SANCTUARY
TRISUL
NANDA KHAT
I
II
III
VEGETATION DISTRIBUTION
Forested Areas
Burnt Forests
Pastures and Alpine Meadows with Junipers.
I Entry open to flocks
II Poachers' foot path
III Riverside entry by Expeditions.
--- Path followed by Investigator.

Map 2. Nanda Devi Basin: Vegetation Distribution.

The trees are large and such well-preserved old trees are not likely to be found elsewhere in the Western Himalayas. A very distinctive feature of this beautiful forest is the trailing lichen festooning the trees. The understorey of the forest is formed by the shrub rhododendron *Rhododendron campanulatum*, which produces profuse flowering in early May. Most of the flowers had withered by the time we entered. This earlier flowering of the rhododendrons is an indicator to the light winter snow. The last of the birch trees petered out at the entrance to the Inner "Sanctuary".

Between the tree-line and the permanent snowline, at greater altitude in the "Sanctuary" than on its exposed outer walls, are extensive meadows of Himalayan grasses and a rich variety of flowering herbs. The warmer southern aspect has extensive growth of Juniper *Juniperus* sp. In the last week of March, the meadows were bleak and without any greenery apart from the evergreen juniper bushes; however, by the second week of June a distinct flush of green started showing and parts of the "Sanctuary" took on the gay appearance of a rock garden. Flowers had begun to appear among screes well above 5000 m. On the way down the Rishi gorge the air was heavy with fragrance and vibrating to the hum of bumble bees and other insects.

The flower meadows of the "Sanctuary" are today the last remnants of the extensive Himalayan pastures before flocks of domestic animals overgrazed them and the magnificent display has to be seen to be appreciated. Here we have still largely undisturbed plant communities which must have reached their climax during the last period of glaciation. The impression gained was that of a distinct flora to that of the rest of the Himalayan chain.

THE FAUNA

If the flora of the Nanda Devi basin impresses the visitor, the plentitude and confiding nature of the larger mountain ungulates amazes and charms him. Shipton, describing the Inner "Sanctuary" in his book 'Nanda Devi', mentions the peaceful herds of Bharal and Tahr several times. It is difficult to imagine outside Tibet, and perhaps not even there in recent years, wild ungulates so fearless of Man. I am yet to see a high Himalayan valley so well populated by wild animals.

BHARAL *Pseudois nayaur* : The Himalayan Blue Sheep is the dominant and the most conspicuous large mammal in the Inner "Sanctuary". Herds were sighted on the steep pastures above the cliffs of the upper gorge and almost every pasture had a herd grazing on open grassy slopes within the Inner "Sanctuary". The animals were all low down the slopes and appeared to be partial to the more gentle grassy meadows than the rocky cliffs, though a few animals were seen on a couple of occasions traversing the almost sheer rock cliffs which form the pedestal for Nanda Devi. Herds of half a dozen heads to those of more than thirty were seen. By and large, the larger herds preferred to remain down the slopes. The smaller herds inhabited the upper. Lone rams with the largest horns were seen close to the snow and their tracks were reported at 5300m.—well above the snowline.

> Observations made of a large herd of thirty-two animals near the "Sanctuary" Camp showed that these were ewes and young rams. All the ewes appeared to be very heavy and on the verge of dropping lambs. The first lamb seen was in the last week of

June. June and July seem to be the period when the majority of young are born. The herd under observation grazed and rested intermittently throughout the day. The sheep did not seem to show discomfort at the strong diurnal winds, though they did reveal a tendency to descend lower in mist and when it snowed. While resting, the younger animals seemed to be drawn to large boulders up which they scrambled and stood very much in the manner of goats. Among themselves, the young males sparred a great deal, frequently butting the flank or the rear of a nearby companion. This would result in an immediate retaliation in most cases, the two combatants rising on their hind-legs before bringing their horns together. On a couple of occasions the sheep were seen rubbing themselves like goats against a rock.

It was possible to approach them closer in an upright stance rather than in a crouched position. On several occasions, they curiously approached the observers hiding behind rocks or in depressions, no doubt to get a look at the intruders. When approached directly, the herd would move slowly up the slope. If, however, the observer approached from above, the entire herd would make a rapid move to get onto higher ground. In all instances, the younger animals showed greater fear and the larger individuals — rams and older ewes—would follow the herd, frequently stopping to look back.

Bharal appear to subsist mainly on grass and tended to browse far less than goats. Judging from the scanty vegetation close to the snowline, it seems these fine sheep can survive on the sparsest of pastures. The presence of small herds and isolated adult rams high up the slopes among the bleakest and windiest screes and snowfields was indeed astounding.

A rough census was undertaken in the Inner "Sanctuary" where, at a conservative estimate, there is a population of 500 Bharal. Reports by local porters and foreign visitors place a further 150 heads in the Trisul Valley, while the Ramani basin and the Dunagiri slopes should have another 100 animals. Adding to these about 70 solitary rams at high altitudes, we can expect a population of 820 Bharal within the "Sanctuary". Observing the facility with which they cross snowfields, leap across raging torrents and negotiate seemingly impassable rock traverses, the Bharal of the Nanda Devi basin must be less circumscribed than is believed and entire herds and individuals assuredly cross the mountain barriers to mingle with and, perhaps, augment herds still surviving outside the "Sanctuary" area.

HIMALAYAN TAHR *Hemitragus jemlahicus*: Shipton mentions herds of Tahr grazing alongside the Bharal. Tahr are as large as the Bharal and have very distinctive horns and long hair. We saw none on the higher meadows. That Tahr exist in the Rishi gorge is quite apparent from the numerous goat-like droppings seen along the trail passing along what is ideal Tahr country. The herds of smaller ungulates which Shipton seems to have mistaken for Tahr are in fact Goral, which do inhabit higher altitudes and are indeed considerably smaller than Bharal.

GORAL *Neumorhaedus goral*: There were several herds of this goat-antelope. The largest herd of 21 occupied meadows south of the "Sanctuary" Camp. Their smaller size and shorter and thinner horns immediately identified them. Goral freely mixed with the larger sheep, though they tended to be more alert and were quick to retreat. They, also, seemed to prefer steeper ground and browsed a good deal off the dwarf rhododendrons and furze clumps.

MUSK DEER *Moschus moschiferus*: From reports and frequent indications noted, the birch forests of the gorge seem to still hold a fairly large population of this much-persecuted deer. The musk deer habitat, however, is considerably restricted as a result of the precipitous nature of the Rishi gorge.

SNOW LEOPARD *Panthera uncia* : I found droppings of a large feline near the snout of the South Rishi Glacier. The turds contained Goral hair. Two Bharal kills were found and a Snow Leopard was reported on a Bharal kill by the St. Stephen's College team near Changabang. The shepherds met on the way out in June, on the Mathuni Ridge, graphically described this leopard, which apparently came for stray sheep and, significantly, the authorities have issued gun licenses to a couple of shepherds as protection against this predator.

BEARS There were no indications of either the Black Bear *Selanarctos thibetanus* in the forests or the Brown Bear *Ursus arctos* above the treeline. Their absence was confirmed by the porters.

Game Birds: Despite a careful watch, no Monals *Lophophorus impejanus* were sighted, though there is ample terrain suitable for their needs. It was a pleasant surprise, however, to hear several Koklas Pheasants *Pucrasia macrolopha* crowing close to camp at dawn just above Lata village. Local peasants readily recognise both these pheasants from illustrations shown to them. They, however, do not recognise any of the Tragopans. That the Monal has declined in the last few years was confirmed by an aged villager from Lata who had considerable knowledge of the natural history of his hills and who had, it seems, accompanied several "Angrez" during his youth. Both the Himalayan Snowcock *Tetrogallus himalayensis* and the Snow Partridge *Lerwa lerwa* were plentiful and confiding on the slopes above the treeline. The latter occupied a slightly lower elevation to the former.

THE HUMAN INTRUSION

It has been only within the last couple of decades that the Himalayan range has experienced a rapid acceleration in exploitation by Man. Thanks to better medical facilities there has been a phenomenal rise in the human population. Roads today penetrate all the major valleys and are being added to continually. More and more people are consequently visiting the Himalayas from the Indian plains and abroad. The Nanda Devi Basin has also started receiving a greater attention. Till 1934, and two decades after, only Dibrughetta and Dharasi were regularly visited for a short period in summer by a few shepherds from Lata. The rest of the area was as unexplored as other remoter areas in the Amazon Basin or the Antarctica. Shipton and Tilman pioneered a way up the gorge to the foot of the mountain, to be the first to speak of the extensive pastures and herds of wild ungulates. Their accounts gave wide publicity to the mountain wilderness and surrounded the mountain with an aura only a few much higher peaks like Everest or Kanchenjunga enjoy. If geographical configuration kept local villagers out, political exigencies delayed exploration further. The Nanda Devi "Sanctuary" though enjoying no legal status as a sanctuary is, in fact, one of the world's finest wilderness areas. Unfortunately, unwise exploitation has started and is likely to increase manifold in the years ahead. It is therefore worth evaluating the nature of this intrusion.

Shepherds of Lata, Reni and a few other nearby villages in the Dhauli Gorge have been traditionally bringing their flocks across the 4250m. high Dharasi Col along a precarious defile. They cross over in the first week of June after the winter snow melts on the ridge, and graze the pastures of Dharasi, Malthuni Ridge and Dibrughetta. They prepare to vacate these high pastures in September. The area grazed is a fraction of the Nanda Devi Basin.

While they have not extended their area of operation, I learnt that many more flocks have started using these pastures as a result of the closure of the more extensive Tibetan grazing lands following the Chinese takeover. The Forest Department charges a fee of Rs. 1/- per sheep and Rs. 2/- per goat. There appeared to be no check on whether more goats and sheep were in fact not being grazed than were paid for. Information available states that flocks are coming from as far away as Malari in the upper Dhauli Ganga valley. The Malthuni grazing ground alone had four thousand animals!

With the present pastures being overgrazed, it is but a matter of time before some enterprising shepherd leads his flock further up the Rishi gorge from Dibrughatta along the trail now visible thanks to the flocks of load carrying goats and sheep to Ramani and the Trisul valley. With expeditions relying more on sheep and goats to carry in supplies, the trail has become well demarcated and a greater number of shepherds are becoming familiar with the gorge. It may be pointed out that there are no legal restrictions on their grazing their flocks anywhere within the area. With expeditions wanting access earlier to have more operational time on the mountain before the onset of the monsoon, the Dharasi trail is "forced" by a fortnight.

Plant Gatherers: Many high altitude plants have aromatic qualities and their underground parts have been valued for the preparation of incense, and Ayurvedic medicines. Quite a few are used as ingredients in allopathic preparations. Shepherds always have collected such plants to earn a little extra. With a greater demand and higher prices being paid, more and more of the poorer landholders and landless people are resorting to collecting such plants. While in themselves posing no threat to wildlife, they help pioneer difficult routes and the frequent encounters with wildlife makes them important guides and accomplices of the itinerate poacher. We met several plant gatherers who seemed to be familiar with the remotest tracks.

Poachers: As more and more persons gain familiarity with the gorges, and more easily accessible areas get depleted of wildlife, the attention of the poacher turns to the last remaining herds in such secluded areas. With the price of musk having reached an all-time high, a week or two of hard living is no deterrent to the poacher. The shepherds, already holding firearm licences and spending a summer within the area are assuredly tempted to poach. Ample indications of poacher activity was noted. An expedition member going out of the "Sanctuary" earlier than the rest was followed down the difficult upper gorge by two armed men (personal correspondence); the St. Stephen's College party found remains of a Musk Deer and signs of a hastily abandoned camp between Ramani and Deodi; I came across half a dozen skulls of Bharal which had been severed from the body and left behind on the meadows above the "Sanctuary" Camp, where I also stumbled onto a rock shelter which had all the signs of recent use. Three carcasses, two of animals dying of natural causes and one a predator's kill, were found. They all had the skeleton and sections of the hide attached to the skulls. There exists a "shikaris" trail parallel to the regular shepherd passage across the Dharasi Col. This trail is at a lower altitude and can be negotiated at all times of the year except in mid-winter.

That poaching activity is of recent origin is apparent from the confiding nature of the Bharal and the frequent signs of Musk Deer.

Mountaineering Expeditions and Tourist Parties: The Nanda Devi has always been a very desirable mountain thanks to its great beauty and the mystery surrounding it as a result of the natural barriers. When mountaineering activity revived after the Second World War, the hitherto closed Nepal opened its borders and the attention of foreign mountaineers was drawn to that largely unexplored stretch of mountains. Also, the Government of India excluded all foreign expeditions from the Gharwal Himalayas. However, in the '60s Indian mountaineering came of age and both civilian and military expeditions have been active all along the Indian Himalayas. The Nanda Devi area has received their full attention as attested by a permanent wooden bridge built over the Rishi torrent at Deodi and the graffiti etched and scrawled on rocks and trees. Reports, confirmed by local men who portered for these expeditions, indicate that firearms were often carried in and Bharal meat was on the menu!

With the declaring of the Nanda Devi Basin as a free area, a spate of foreign expeditions have been operating here. The mountain has to be "booked" several years in advance! Apart from Nanda Devi, there are several other attractive mountains within the basin. At least two of these foreign parties had a local "shikari" among their porters. They hire as many as 40 or more porters and several hundred baggage goats. The impact of the operations by four expeditions in one season can well be imagined. This summer, besides the British expedition with its 30 odd porters and 300 baggage animals, there was a Japanese expedition on Trisul from the south, a German trekkers-cum-climbers party on the same mountain from the north, the St. Stephen's College Devistan-Changabang expedition and a Mountain Travel's party of American tourists to Nanda Devi. Both the German and a second Japanese party came up the Rishi Gorge which is being progressively used as an alternative to the traditional high route. All these parties had more porters and baggage animals than our expedition! In addition, we met several trekkers with their porters; the Rishi Gorge had a continual passage of men. While foreign expeditions are registered with the IMF (Indian Mountaineering Foundation), there are no checks whatsoever on trekking parties, individual trekkers and Indian expeditions.

The traditional trail over Dharasi Col is, as mentioned earlier, forced by the middle of May. The route by the gorge is being more regularly used and the "shikaris" trail below the Dharasi traverse is regularly frequented. From Dibrughetta to Ramani a well-defined and an extraordinarily even-graded trail now exists. Even the Shipton-Tilman track up the upper gorge is better defined and can be traversed with care by single men and I crossed the formidable "slabs" unaided, wearing canvas boots! All in all, the natural defences of the "Sanctuary" have been effectively breached.

Future Development Plans: With the greater number of expeditions to the area and foreign agencies promoting trekking parties to Nanda Devi, the high tourist potential of the "Sanctuary" has been realised by local operators and a convincing argument for the construction of a bridle-path up the Rishi gorge up to Deodi has found favour with the authorities. A ground survey has been undertaken and the project has the backing of the Gharwal Mandal Vikas Nigam, a body set up by the U.P. State Government to advise opening up of Gharwal for tourism.

With the construction of a bridle-path up the gorge, further development will assuredly follow as for example, converting the bridle-path into a jeep track, construction of tourist huts and bungalows, etc. The Rishi Gorge, flowing at several hundred metres above the Dhauli Gorge is separated from it by the very narrow Lata Ridge and offers considerable possibilities for a hydro-electric project involving a short tunnel to divert the Rishi. Any development programme initiated without due recognition of the uniqueness of the Nanda Devi "Sanctuary" will result in the loss of a magnificent heritage.

CONSERVATION CONSIDERATIONS

The Fragile Ecosystem: Mountains are subjected to greater erosional activity, particularly so when they are seismically active young structures as the Himalayas are. The gravitational force is more potent on steep mountains and greatly intensifies the action of rivers, glaciers, snow avalanches, landslides triggered off by water seepage, and wind. The extremes of temperature at great altitudes shatters the rocks and further adds to the instability of mountain areas. Despite the combined onslaught of elemental forces, vegetation tends to stabilise slopes and to cover exposed rock faces. There were far less unsightly scars within the "Sanctuary" than in inhabited, less rugged areas. The steepest sides were densely covered by plant growth, forests, shrubberies, herbs and grass, which even more effectively held the soil. It was only where torrents and snowslides came down that there were no plants. Wherever the screes had become slightly stable, plant life had started colonising them and hardy high-altitude plants grew in sheltered places well above the permanent snow fields.

The vegetation cover of the Himalayan slopes is at the very best very fragile and develops a precarious balance which the least bit of change by natural or man-induced causes can upset. The balance may take years to be established again. The vulnerability increases with the steepness of the slopes and the altitude. The entire study area is exposed, therefore, to the maximum effect of erosional forces. An added factor is the general aridity of the soil, which is liable to be blown away by wind. The harsh and dry climatic conditions make regeneration by plants more difficult. In the upper gorge, the narrow trail was possibly the same pioneered by Tilman and Shipton, its stability provided by springy turf and large clumps of grass.

The almost continuous cover of juniper on southern aspects afforded protection to the loose soil above the treeline. Above the juniper level, clumps of *Caragana* (furze bush) played the same role. The tussocks of grass so characteristic of Himalayan high-altitude pastures, are to be seen at their best here and are an effective protection to the soil. That regeneration, however, takes greater time here than elsewhere is demonstrated by the well-demarcated trail along the upper gorge, which, in areas of rapid plant regeneration, would easily be obliterated in one season.

Many of the trees, shrubs and herbs have aromatic oils and burn easily. The long grass is dry and inflammable in March and

June. Fire, therefore, has to be considered a very major hazard to the ecosystem. Burnt slopes are effectively exposed to erosion forces and become extremely unstable as a result.

The Vulnerable Fauna: It is now a known fact that in harsh environments only a few forms of life survive by virtue of a high degree of adaptation, and these highly successful forms increase in numbers to fully utilise the habitat. High mountain habitats are congenial to life only for the summer months and the period is shortened with the altitude. Most of the birds and many of the flying insects move up only during the summer. Others suspend activities during the harsh months and hibernate; even mammals undergo varying periods of winter sleep. Within our area there are several rodents and a few skinks—reptiles, which so escape the harsh winters. However, resident birds like the Snowcocks and Snow Partridges, the ungulates like the Bharal and Goral and the Snow Leopard which preys on them are active in the worst weather. Under very severe conditions they may move to lower altitudes. Within the Nanda Devi Basin, this downward movement is restricted by the configuration of the enclosing ridges which press the herds towards the gorge. It is the fat accumulated during the summer grazing which permits them to survive the harsh winter. The least bit of disturbance can easily upset living conditions and place an entire species' continued survival in jeopardy. This factor needs to be emphasised if the need for control of human activity is to be convincingly advocated. A brief discussion on the mere presence of human beings at "Sanctuary" Camp in May and June would suffice our purpose.

The month of May, as we found, is still rather bleak and it is only in mid-June that fresh grass starts sprouting. The herds of Bharal—the ewes heavy with lamb and young males—are all confined to the lower pastures through which the path up to Nanda Devi base camp passes. As the green flush extends up the slopes, the animals follow up the slopes to reach the higher pastures by August and September, by which time the ewes are followed by their newborn lambs and the territories of the Master Rams are reached and rutting takes place. During the summer, plenty of body fat is accumulated. The continual movement of expeditions in the summer months can endanger the species, since they are compelled to move off the best pastures at a time when forage is at its lowest. The pregnant ewes are placed under stress just when they should have the least disturbance. Though not substantiated by statistics, it is quite apparent that even if there is no killing by poachers there are chances of the wild sheep declining as a result of human activity on their summer pastures. What is true of the Bharal is true of the Goral, and any reduction in the numbers of the two ungulates would directly affect the Snow Leopards.

The removal of juniper brush, apart from causing erosion, destroys the sheltered habitat for insects and the small birds which find food and nesting sites there. Indirectly then, as a result of habitat degeneration, birdlife also is affected. Fires add to the hazards and since birds nesting at high altitudes have a short period for raising their young, any destruction of eggs and young would mean a total failure of nesting for that particular season.

IMPACT OF HUMAN ACTION

Grazing by Domestic Flocks: There is quite apparent degradation of the grazing grounds of Dharasi and Dibrughetta. The pressure on these traditional pastures has increased and is increasing. The number of heads brought in is already far too high. with more than 4000 (personal discussion with shepherds) heads of goats and sheep. In addition to the usual flocks, several hundred animals carrying expedition baggage pass through. Apart from depleting the forage, the passage of animals, often almost vertically down slopes, results in a series of very ugly landslides. A huge scar has formed on the eastern slope of the Malthuni Ridge which is in an active state of shifting. Vegetation has no chance of stabilising on it since flocks graze over the area and renew the disturbance each year. Similar landslides, resulting from passage by sheep and goats, has set in even in forest country.

Deforestation: Each expedition hires large teams of porters. With an average of 50 porters per expedition and four such expeditions operating in one season, 200 men move up and down the gorge. These men, out of necessity, collect firewood for cooking and since they are all lightly clad and tents are not provided, have to seek warmth through the night from fires. The consumption of firewood each season can be appreciable. Above the timberline, juniper is the chief source of fuel and considerable sections of juniper have been cleared. At all the regular campsites, dead wood has long ago been utilised and trees have to be felled. This is particularly pronounced at the Deodi and Ramani campsites.

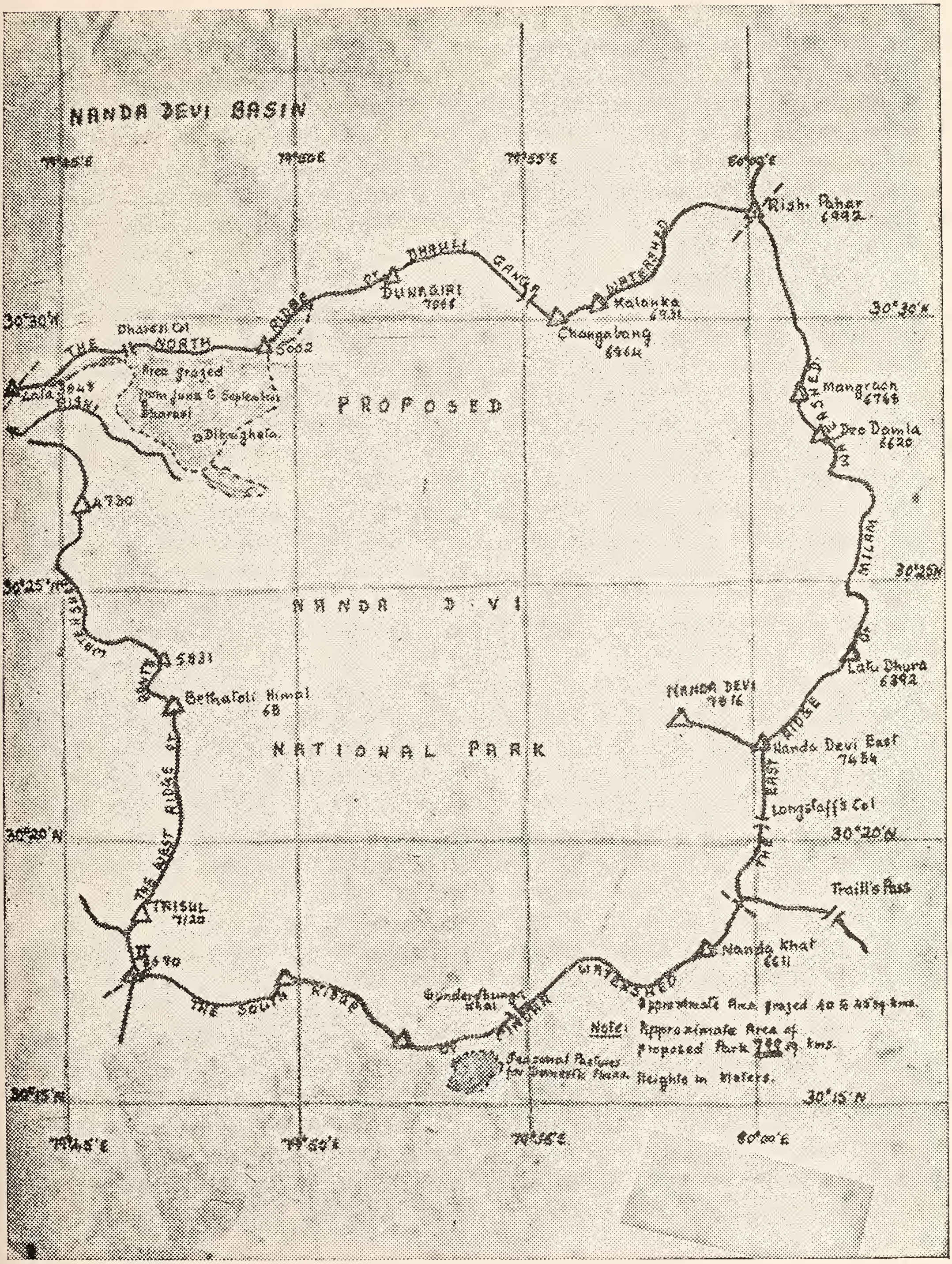
Fires: Many of the porters light fires at the base of trees; this sets the heartwood on fire and we noticed several smouldering trunks. Such practices obviously cause forest fires and all along the trail we noticed large sections burnt. The greatest damage by fire was seen at Dibrughetta, where almost 25% of coniferous forest is burnt! The shepherds in charge of load-carrying flocks fire the long grass to permit their animals to get at green sprouting grass. These fires rapidly spread up the slopes and die out only at the upper limit or a cliff edge. Clumps of juniper burst into violent flame, adding to the upward spread of the flames. Since there are no forestry practices within the "Sanctuary", these fires are uncontrolled; nor are the burnt sections replanted. Ugly scars of old and recent fires all along the trail were a marked and depressing contrast to the green stands of forest on the opposite side of the gorge.

Poachers: Poaching within the basin is of fairly recent origin. However, conditions are now ideal for this evil to flourish. The sale of animal pelts has been a regular trade along the pilgrim route. With roads now permitting vehicular traffic right up to Badrinath, the numbers of affluent and not very pious tourist pilgrims have increased. These are notorious curio-buyers and the sale of pelts is brisker than before. This ready outlet is augmented by the large military and paramilitary forces stationed throughout the year in the upper valleys. The sale of mutton is an additional inducement for poaching. Shepherds who formerly left carcasses of their flock dying of forage poisoning, now find it worth their while to carry the carcasses down to the road-head in the Dhauli gorge. With prices of Rs. 300/- per animal being paid for a goat or a sheep, a dead Bharal offers high returns to a poacher. Musk Deer have always been severely persecuted and a single animal shot can yield a fortune. The investigator was told by very reliable sources that a well-organised group operates at Dehra Dun, who handle the smuggling of raw musk pods collected in the Gharwal Himalayas. If till recently, poachers were not active within the "Sanctuary", it was because there were other more easily accessible targets, and the terrain was less frequented. Conditions have completely changed and the wildlife of the "Sanctuary" is exposed to the depredation of poachers.

Litter: Though not of consequence to the welfare of wildlife, it is a depressing sight, worth mentioning here, that all the major camping sites have taken on the appearance of mini-urban refuse dumps. Even streams from where drinking water is drawn are not spared, and they were choked with plastic sheets, toilet paper, cartons, egg-shells, tins, etc. While expeditions do try to collect their refuse in one place, the commercially operated trekking parties have no such compunctions, since their interest in the place is short-lived. Campsites used by one such trekking party were left completely littered and unusable. It is quite apparent that even those who profess to love the mountains are not over-concerned about the impact of their passage on a trail.

The Positive Human Factor: Perhaps the greatest error committed by exponents of conservation of wildlife in this country has been the almost complete lack of awareness or appreciation of local sentiments and the innate intelligence of the peasants to understand the value of conservation for their own survival. The Gharwali, like all hillmen, is a very pragmatic person. He is also very much alive to the wildlife around him being a shikari. He is a person, who, though cautious in accepting new ideas, can certainly be expected to participate in any planning for the betterment of his own life. The social organisation of his village has been a close-knit one because of having to cope with a difficult terrain. The proof of this can be had from the "Chipko Movement", which has no parallel anywhere else in the country. Significantly, the epicentre of this remarkable conservation oriented mass action is at Reni and Lata villages and involves the excellent forests in the Ronti Valley—physically a part of the Nanda Devi Basin. The movement was sparked off by a contract for clear-felling and the satyagraha was spearheaded by the housewives of the two villages. This unique action has made the villagers aware of their rights to their village territories. The heartening aspect of the satyagraha was not based on economical needs but on the highest of conservation principles—saving the forests to combat floods and landslides! Unlike the forest tribes of peninsular India, the Gharwali is a diligent farmer and carefully constructs terraces to retain his valuable soil, is fully alive to the value of forest litter as manure and constructs extensive irrigation channels. Being devout Hindus, he considers the Bharal herds as property of Goddess Parvati, the consort of Lord Shiva and the Nanda Devi peak is held in veneration as the physical form of the Goddess. Significantly too, the villagers are very alive to the value of the "Sanctuary" as a tourist draw and there is considerable resentment over expeditions bringing in "Sirdars" and high altitude porters from elsewhere. Significantly, the promotion of tourism is handled by the Gharwal Mandal Vikas Nigam, which is headed by a Gharwali who impressed the investigator by his interest in nature.

Favourable Legal Status and other considerations: Unlike other Sanctuaries and National Parks in the country, the entire Nanda Devi "Sanctuary" is free of human settlement. Even grazing rights are very


NANDA DEVI BASIN
79°45'E
79°50'E
79°55'E
80°00'E
30°30'N
30°25'N
30°20'N
30°15'N
Rishi Pahar
6992
THE NORTH RIDGE OF DHAULI GANGA WATERSHED
Dunagiri
7066
Kalanka
6931
Changabang
6864
Dharansi Col
5002
Area grazed
from June & September
Dharansi
Dibrugheta
Lata 3948
Rishi
4730
PROPOSED
NANDA DEVI
NATIONAL PARK
WATERSHED
5831
Bethartoli Himal
68
THE WEST RIDGE OF
TRISUL
7120
6890
THE SOUTH RIDGE OF PINDAR WATERSHED
Sunderdhunga Khal
Mangraon
6768
Deo Damla
6620
WATERSHED OF MILAM
Latu Dhura
6392
NANDA DEVI
7816
Nanda Devi East
7434
THE EAST RIDGE
Longstaff's Col
Traill's Pass
Nanda Khat
6611
Approximate Area grazed 40 to 45 sq. kms.
Note: Approximate Area of Proposed Park 788 sq. kms.
Seasonal Pastures for Domestic Stock
Heights in Meters.

Map 3. Boundaries of Proposed Nanda Devi National Park.

seasonal and affect a fraction of the area. Human exploitation has very recently started and this, too, is of high tourist potential. The boundaries are clearly demarcated by effective natural barriers and are effective against trespass. Conservation planning for the area can result in considerable economic gain to the villagers.

RECOMMENDATIONS

Immediate representation needs to be made to the State Government to suspend all development projects involving the study area, impressing them of the scope for proper well-planned utilisation of the tourist value of the area and that considerable damage will be sustained by the magnificent habitat and its wildlife if persons with shortsighted interests are allowed to initiate exploitation. No developmental programmes are to be considered without taking into consideration the following.

Legislation: The Uttar Pradesh Government be asked to declare the Nanda Devi Basin a Wildlife Sanctuary[2] for high altitude flora and fauna, to protect India's only wilderness area and its large herd of Himalayan Blue Sheep and viable populations of Musk Deer and Snow Leopards, both highly endangered species. Subsequent action by the State Government be requested to upgrade the new Sanctuary to the status of India's first Himalayan National Park. The boundaries suggested are (See Map 3):

(i) The Northern Boundary or the Dhauli Watershed to run along the ridge from Lata Peak, the Dharasi Col, Dunagiri, Changabang, Kalanka to Rishi Pahar in the east.

(ii) The Eastern Boundary or the Milam Watershed to coincide with the boundary between Chamoli District and Pithoragarh District along the crest from Rishi Pahar to Nanda Devi East and onto the bifurcation where the Traill's Pass Ridge separates.

(iii) The Southern Boundary or the Pindar Watershed to coincide with the boundary between Chamoli District and Almora District along the divide from the bifurcation of the Traill's Pass Ridge, over Nanda Khat and Mrigthuni and onto Trisul II.

(iv) The Western Boundary to run along the main Trisul Bethertoli axis and on along the Ronti-Dudh Ganga watershed down to the Rishi opposite Lata Peak.

Entry Restrictions: The Nanda Devi "Sanctuary" once again be declared a restricted area and all visitors be required to register with the Police at Joshimath and entry permits be issued by the authorities. These permits should be liable to be checked at Lata Village or within the "Sanctuary" by Forest Guards. All entry must be restricted to the traditional route over the Dharasi Col and the route up the gorge be completely banned. Nor should visitors be permitted to enter by the "Shikaris" trail (see sketch Map 3). The "Sanctuary" should be open to visitors from 15th May to 30th September. All visitors must vacate the area latest by 1st October.

Expeditions should only engage porters and load-carrying flocks must not be permitted across the Dharasi Col.

Grazing permits should be issued for a fixed number of animals and the heads of sheep and goats physically counted at Lata Kharak before being allowed to proceed beyond the Dharasi Col. Grazing permits must be issued only to flocks belonging to Lata, Reni and the nearby villages.

Total ban on Firearms: All firearm licences to shepherds grazing flocks within the "Sanctuary" must be withdrawn. Sheep dogs are effective deterrents to Snow Leopards as admitted by the shepherds questioned—all the dogs with the Malthuni herd did not have protective collars. No expeditions or other persons should be permitted to carry in firearms.

Porters: All porters engaged by expeditions must be registered with the Lata Panchayat and hiring porters from other parts of the Himalayas must be discouraged. Should expeditions desire to bring in outside men, they should have to pay the same entry fee per porter as would be charged to Indian visitors.

Entry Fee: All visitors to the "Sanctuary" other than local porters and permit-carrying shepherds must pay an entry fee. Indian visitors should pay Rs. 50/- per person; foreign tourists Rs. 250/- per individual.

Peak Fee for Expeditions: Foreign expeditions to the "Sanctuary" should be required to pay peak fees of Rs. 5000/- for Nanda Devi and Rs. 2000/- for other peaks. Indian expeditions should pay a flat expedition entry rate of Rs. 1000/-. These fees should be charged in addition to the personal entry fee. Trekking parties sponsored by travel agents should pay a fee of Rs. 5000/- per party in addition to the personal entry fee.

Liaison Officers: All foreign expeditions and trekking parties by travel agents must be assigned a liaison officer of standing, who is either deputed from the Services or a person recommended by such organisations as the Himalayan Club, World Wildlife Fund-India or the Bombay Natural History Society.

Registering "Sirdars" and Porters: All expeditions and trekking parties, foreign or Indian, must engage registered "Sirdars" from the nearby villages. These "Sirdars" should be given intensive training at the Nehru Institute of Mountaineering, Uttar Kashi. All porters from Reni and Lata should be registered and issued special identity cards from the NIM through the Magistrate at Joshimath. Porter rates, etc., should be fixed after discussions with the village Panchayats.

Fuel: Expeditions must be required to carry in Kerosene for the team members and porters. Individual trekkers may, however, be permitted to use firewood. Only fallen deadwood should be used for fuel. A special cooperative store should be opened at Lata from where expeditions may purchase provisions for the porters, kerosene, etc., at fixed Government rates.

Tourist Accommodation: Clean, cheap accommodation should be developed at Reni and Lata. Villagers should be encouraged to provide accommodation and financial assistance be made available to them to expand their facilities. Provision should be made to provide camping equipment on hire at Reni.

Warden and Guards: The Forest Department should appoint a Sanctuary Warden with his headquarters at Reni. He should be assisted by at least four guards. All five men must receive training at NIM. During the open season three guards should be stationed, one each at Dharasi Col, Malthuni Ridge and Patalkhal. The fourth guard should remain at Lata. Each guard should be assisted during the season by other guards deputed for anti-poaching training by the Forest Department and/or the Police. The military and paramilitary forces may be requested to depute jawans as well.

The guards should be issued portable wireless sets and light arms. They should each have a pair of Himalayan Mastiffs and be equipped with light mountain tents, sleeping bags, protective clothing and binoculars.

Porters wanting to be registered as "Sirdars" should be required to undergo a month of guard duty. College students may be encouraged to volunteer as assistant guards under the NSS scheme.

Conservation Action: The Forest Department must immediately undertake to replant the burnt areas with appropriate trees and also consider establishing nurseries of junipers for transplanting on slopes denuded of natural growth as at "Sanctuary" Camp. The assistance of voluntary groups like the "Chipko" volunteers might be considered.

The half burnt timber should be felled and the logs used to demarcate the sides of a carefully graded sheep trail wherever the descent is direct and steep initiating landslides similar to that on the Malthuni Ridge.

Special refuse disposal pits should be prepared at all important campsites and inflammable material periodically burnt and iron cans, etc. buried.

A systematic study of the area should be initiated with a view to developing a sound management programme for the proposed National Park.

Simple guide booklets be developed on the "Sanctuary" in Hindi, English, German and Japanese, which should be available at the co-operative store at Lata and the Sanctuary Warden's office at Reni. This booklet should briefly describe the main flora and fauna likely to be seen along the trail and provide conservation guidelines for the visitor.

ACKNOWLEDGEMENTS

I am most grateful to the World Wildlife Fund—India for sponsoring and planning my visit to the Nanda Devi Basin and for granting me long leave for the purpose.

Mr. John Millar has to be thanked for having got me invited as a member of the 1977 British Nanda Devi Expedition. While all the expedition members were extremely kind and helpful at all times, I greatly value the close friendship which emerged between Len Smith, the Deputy Leader and Treasurer of the Expedition, and myself.

Special thanks are due to all the members of the British Army Team, which had accompanied the Expedition. Significant contributions to my enquiry were made by Rt. Hon. Captain Jonathan Forbes. Capt. Roderic Wyn-Pope and the other members were all extremely helpful and hospitable.

Much though I would like to mention names of officers of the Army at Joshimath for their great kindness to me, security restrictions prevent my doing so. Shri K. S. Fonia, General Manager, Gharwal Mandal Vikas Nigam, gave me considerable information regarding development plans of the region; to him go my thanks.

Shri Nalni Jayal, Joint Secretary in charge of wildlife and forests, Ministry of Agriculture, New Delhi, gave me considerable encouragement while Shri Jagdish Nanavati, Hon. Secretary of the Himalayan Club provided me with relevant information. He was most generous with his valuable time.

I must express my appreciation for young Nanak Chand of Manali, who acted as my personal porter, cook and guide. Without him, I would not have been able to get the many good photographs of Bharal and flowers.

THE ITINERARY

Note : *Rainy Days

*15th May	Assembly at Lata Road Head	ac. 6,500′
*15th May	Bhelta Forest Camp	ac. 7,000′
*16th May	Bhelta—a search for pheasants in forest.	
*17th May	Lata Kharak	ac. 12,000′
*18th May	Lata Kharak	
*19th May	Dharasi Col-- held up by blizzard	over 14,000′
*20th May	Dharasi Col—held up by blizzard	
*21st May	Dharasi	ac. 13,750′
22nd May	Dibrughetta	ac. 11,000′
23rd May	Deodi	ac. 11,000′
24th May	Ramani	ac. 11,640′
25th May	Patalkhal	ac. 14,500′
26th May	Sanctuary Camp	ac. 14,600′
26th May) to) 13th June)	Survey of Inner "Sanctuary"—almost daily afternoon cloud. Four days of snowfall. Monsoon current set in by 6th June.	
*14th June	Patalkhal	
*15th June	Patalkhal—held up by snowfall.	
16th June	Ramani	
17th June	Deodi	
*18th June	Dibrughatta	
*19th June	Malthuni Ridge	ac. 14,000′
20th June	Bhelta Forest	
*21st June	Lata Roadhead	

PARAMBIKULAM WILDLIFE SANCTUARY AND ITS ADJACENT AREAS

V. S. VIJAYAN[1]

INTRODUCTION

Location, Extent and Topography:

The Parambikulam Wildlife Sanctuary came into existence in 1962, when a small area—Sungam range—was declared a sanctuary. In 1973, more areas were added to it and at present it covers an area of about 235 km² (10°25′ N, 76°43′ E) in the Palghat District of Kerala at an elevation of 600 metres above sea level. On the east it is contiguous with the Anamalai Wildlife Sanctuary of Tamil Nadu; on the north-west it is bordered by the Nelliampathy reserves of Nemmara Division and on the south-west and south by the Vazhachal and Sholayar range respectively, of the Chalakudy Division.

Sholayar is contiguous with Parambikulam on the south and is separated from Parambikulam by a lofty ridge; the highest peak, the Karimalagopuram, has an elevation of 1,440m.

Sholayar range has an area of 15,513.60 hectares, of which 1,820.73 hectares have been leased out for Sholayar Dam and also for tea estates. The rest is reserved forest. The whole area is hilly in character with numerous rolling hills, peaks and cliffs.

There are three dams inside the sanctuary area; Parambikulam, Thunakadavu and Perivarapallam dams (Table 1).

TABLE 1

DETAILS OF THE DAMS IN PARAMBIKULAM

Name of dam	Waterspread area	Catchment area
Parambikulam dam	21.29 Sq. Km	230.51 Sq. Km
Thunakadavu dam	4.34 Sq. Km	43.36 Sq. Km
Perivarapallam dam	2.90 Sq. Km	15.80 Sq. Km

The two major river valleys in the area are of the Parambikulam and Sholayar rivers which converge at Orukombankutty and flow into the main Chalakudy river. Parambikulam drains the southern portions of the Nelliampathy reserve while the Sholayar drains the further reaches of the Adirapalli reserve.

The only approach to the sanctuary by road is from Pollachi, about 48 km from Thunakadavu, the headquarters of the sanctuary. This road passes through the top slip area of the Anamalai Sanctuary. The proposed Chalakudy-Vazhachal-Parambikulam road would increase the accessibility from Kerala side. However, this would also give more opportunity for poaching. A unique forest tramway was in existence here from 1907 solely meant for timber transport from Parambikulam to Chalakudy. Later on it was found that the annual expenditure for maintaining the tramway was quite high and it was a problem to supply sufficient quantity of timber for transport by the tramway in order to enable it to be worked without loss. Extensive extraction of timber

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took place during this period and finally a stage was reached when timber had to be extracted to maintain the Tramway! Finally, after several years, it was abandoned. However, the tracks, if properly maintained, would be a blessing to naturalists for watching birds and viewing animals.

HABITAT AND VEGETATION

Parambikulam Wildlife Sanctuary has a wide variety of habitats, both natural and man-made. The former consists of evergreen and moist deciduous forests, grassy hills and swampy areas, locally known as Vayals which are very common. The Vayals are generally surrounded by hills and forests and as the drainage in this area is particularly poor, there is an accumulation of clayey loam resulting in a semi-marshy condition. Grass grows luxuriously in this area and elephants and gaur are greatly attracted to this habitat. Man-made habitats in this area are derived mainly from Teak plantation. Eucalyptus is also raised and Tapioca cultivated in newly felled areas.

The vegetation of Parambikulam which has been studied by Sebastine and Ramamurthy (1966) is a combination of Malabar and Deccan elements. Malabar elements occur in the evergreen patches mainly in the valleys and moist regions of the area. In Sholayar the vegetation is mainly evergreen. Deccan elements are dominant in the moist deciduous forest. *Cullenia exarillata, Myristica fragrans, Hydnocarpus wightiana, Dillenia* sp., *Aporosa lindleyana, Cinnamomum* sp., *Herpullia arborea, Hydnocarpus laurifolia, Diospyros assimilis, Diospyros malabaricum, Adinosa* sp., *Baccaurea courtallensis, Machilus macrantha. Vateria indica. Mesua ferrea* are common in the evergreen forests while *Adina cordifolia, Careya arborea, Grewia tiliaefolia, Pterocarpus marsupium, Dalbergia latifolia, Melia* sp. are common in moist deciduous forest. *Clerodendron infortunatum, Fluggea* sp., *Glycosmis pentaphylla, Helicteres isora, Lantana camara* and *Randia dumetorum* are common undergrowth in moist deciduous forest. Lantana grows thickly in cleared areas and lush growth of *Eupatorium* was noted in Teak plantations, especially where the plantation has failed.

Plantation:

Parambikulam was one of the typical teak areas of the State and the best natural teak was found in this region. But the extensive extraction during the last several years has depleted this area of its once famous teak and rosewood. The first plantation in this area was raised about 1912. The majority of the plantations lie along the first section of the tramway line where clearfelled areas had been regenerated artificially with teak. All the plantations after 1932 were raised under taungya system. Eucalyptus is also planted here on a small scale. At present, 100 Sq. Km of the sanctuary are under plantation.

WILDLIFE

Parambikulam Wildlife Sanctuary and the Sholayar area have almost all the representative Peninsular Indian animals, (Table 2). Pug marks of 6 tigers, 3 in Parambikulam sanctuary and 3 inside Sholayar range, were seen. Apart from tiger, the other endangered species seen here are Liontailed macaque and Nilgiri tahr, 76 of the former and 32 of the latter were recorded from the sanctuary area.

TABLE 2

ANIMALS RECORDED FROM PARAMBIKULAM/SHOLAYAR AREA

Species	Seen	Heard	Spoor	Remarks
Presbytis johni (Nilgiri Langur)	238	5	—	—
Macaca silenus (Liontailed macaque)	76	1	—	—
Macaca radiata (Bonnet macaque)	29	—	—	—
Panthera tigris (Tiger)	—	—	6	3 at Parambikulam 3 at Sholayar.
Panthera pardus (Panther)	—	—	2	Both at Parambikulam.
Paradoxurus hermaphroditus (Toddy cat)	—	—	1	Sholayar.
Herpestes edwardsi (Common Mongoose)	1	—	—	Moist deciduous forest, Parambikulam.
Cuon alpinus (Wild dog)	—	—	2	Droppings at two places Evergreen forest.
Melursus ursinus (Sloth Bear)	—	—	5	3 from teak plantation. 2 from open area only dropping.
Lutra sp. (Otter)	2	—	—	—
Martes gwatkinsi (Nilgiri marten)	2	—	—	Sholayar.
Ratufa indica (Giant squirrel)	45	7	—	Various habitats Parambikulam and Sholayar.
Hystrix indica (Porcupine)	—	—	1	—
Elephas maximus (Indian Elephant)	11	—	—	Dung and tracks were not counted.
Bos gaurus (Indian gaur)	40	—	1	—
Hemitragus hylocrius (Nilgiri tahr)	32	—	—	—
Cervus unicolor (Sambar)	13		3	2 tracks in Sholayar. 2 killed by wild dog not added.
Axis axis (Spotted deer)	8	—	—	2 fawn seen singly on different days. 6 Ad-M. deciduous forest.
Muntiacus muntjac (Barking deer)	5	5	1	2 at Sholayar.
Tragulus meminna (Mouse deer)	—	—	2	1 dropping 1 hoof mark.
Sus scrofa (Wild Boar)	70	—	—	3 sounders of 12, 40, 15, rest singly.

Nilgiri Langur *Presbytis johni*

238 animals were seen in 30 troops, the largest troop had 11 individuals. 8 solitary individuals were seen. On several occasions the number of individuals in a troop could not be counted accurately because of the inaccessible nature of the terrain. Troops were seen mainly in sholas and moist deciduous forests, occasionally in teak plantation, adjacent to natural forests. They frequent bamboo clumps too. Though there is no data to compare their population, it is felt that their population has decreased considerably. The number of troops seen during my previous visit to this area in 1972 was apparently higher. Illegal poaching of this protected species from the remotest part of the sanctuary is still going on, as reported by local inhabitants. Habitat destruction is the other major cause affecting their population.

Liontailed Macaque *Macaca silenus*

76 were seen in 7 troops; 4 troops in Parambikulam area and 3 in Sholayar area (Table 3). The average troop size is 10.8. The smallest troop contained 8 individuals and the largest 17. The former was in a small patch of evergreen forest on the western slope of Vengoli mudi near Thunakadavu reserve. This population appeared to be an isolated one since this patch of forest is surrounded by bamboo forest and I saw no indication that they move through bamboo.

The call of Liontailed macaque was heard from Karimalagopuram, but the troop could not be traced. A troop was reported from this area by the Wildlife guides, a month after my observation.

All the 7 troops were seen in evergreen forests. *Cullenia exarillata* was common in all these areas. In Sholayar the trees were in flower during the period of observation and the animals ate the fruits and at times the flower.

Steven Green in his survey of Liontailed macaque has not reported the occurrence of this species in Parambikulam/Sholayar area.

TABLE 3

DISTRIBUTION OF LIONTAILED MACAQUE IN PARAMBIKULAM/SHOLAYAR AREA

Location of Sightings	No. of individuals	No. of Troops
Vengoli mudi shola	8	1
Kuriyarkutty	17	1
Orukombankutty	13	1
Border of Vazhachal and Orukombankutty	10	1
Sholayar range	28	3 (8+11+9)
Total seen	76	

Nilgiri Tahr *Hemitragus hylocrius*

Tahr was observed at three places. Vengoli peak, Karimalagopuram and Pandaravaramalai. Pandaravaramalai is on the east of Parambikulam and largely falls within the Anamalai Sanctuary. Altogether 32 Tahr were seen (Table 4).

Table 4

Distribution of Nilgiri Tahr in Parambikulam area

Vengoli peak	18	One Saddleback
Karimalagopuram	5	1 FY, 1 Saddleback, 1 Brown Buck
Pandaravaramalai	9	No Saddleback was noted.

Gun shots were heard frequently from the foothills of Karimalagopuram, on the northern side, where Tapioca is cultivated intensively. It is said to be to scare away the crop-raiding animals!

Tiger *Panthera tigris*

Pug marks of three tigers were seen inside Parambikulam Sanctuary area and three in Sholayar area. Of the three in Parambikulam, one was seen near a shola in Anapadi beat. Droppings were also seen here and contained Sambar hair. Two of the pug marks were seen in Thellickal beat, both on the road to Parambikulam from Thellickal Rest House, between teak plantations. Of the three pug marks seen in Sholayar area, one was of a large animal.

Elephant *Elephas maximus*

Altogether 11 elephants were seen. Out of the 4 Tuskers noted, one was a single tusker and one other had its tail broken. One calf was also seen. Elephants seemed to prefer teak plantations to natural forests during the period of observation.

Gaur *Bos gaurus*

Of the 41 gaur seen, one herd of 12 and another of 15 were recorded at different places. Three gaur were seen once in a bamboo ings were not as contrasty as in the solitary bulls were recorded. In the herd of 12 individuals, all were either cows or young bulls. Since the pelage was brown, the white stockings were not as contrasty as in the solitary bulls. In the herd of 15, 6 were calves, 2 were adult bulls and the rest females. Largest herd was seen in 'Vayals'. (Table 5).

Nilgiri Marten *Martes gwatkinsi*

A pair of this Mustelid carnivore was seen in the Sholayar area, while the animals crossed a road about 10 ft. away from me. There is no recent record of this animal from Kerala.

Avifauna

The Parambikulam/Sholayar area is very rich in bird life. 133 species were observed during the period of observation (See List Appendix I).

Frogmouth (*Batrachostomus moniliger*) was not recorded earlier from this area. The last authentic record of this bird in Kerala (at Thattakad) was in 1937, by Dr. Sálim Ali. The bird was seen on two consecutive days in a bamboo thicket and was observed very closely. A photograph could not be taken owing to poor light condition. Since the plumage of the bird was cryptic and merged with the surroundings, the bird could not be made out till it moved. The breeding of Dollar bird (*Eurystomus orientalis*) was recorded at Kuriarkutty and also at Periya shola. Open areas with scattered trees and shrubs, near water holes, surrounded by forest is its typical habitat. Nests of *Monarcha azurea, Dicrurus aeneus, Dicrurus hottentottus* were also observed during the study.

TABLE 5

DETAILS OF GAUR OBSERVED IN THE SANCTUARY

Place	Total seen	Herd	Bull	Cow	Calf	Habitat
VENGOLI MUDI PEAK			—	11	1	Moist deciduous forest. Bamboo abundant.
EASTERN SHOLA OF VENGOLI PEAK	1	—	1	—	—	Bamboo.
THELLICKAL	15	1	2	7	6	Vayal.
KACHITHODU	3*	—	—	—	—	Scrub and Bamboo Vegetation.
THELLICKAL	1	—	1	—	—	Near stream. Teak plantation.
KARIMALAGOPURAM	2	—	2 Solitary	—	—	Grassland near Shola.
LEFT SIDE OF EASTERN DAM	4**	—	—	—	—	Grass & Bamboo—Wet swampy area.
KURIYARKUTTY	1	—	1	—	—	Moist deciduous forest.
PANDARAVARAMALAI	2	—	2 Solitary	—	—	Grassland.
	41	2	9	18	7	

* Could not recognise sex, as I got only a fleeting glimpse.

** Could not recognise the sex as they were seen at a long distance.

MANAGEMENT

The administrative set up of the sanctuary is:

DFO : Local Administrative Head
One Assistant Wildlife Preservation Officer : Next to DFO
3 Foresters : One each for Thekkady, Thunakadavu and Parambikulam.
4 Guards : One each for Thunakadavu, Parambikulam, Kuriyarkutty, and Orukombankutty.
3 Watchmen: One each for Thunakadavu, Orukombankutty and Kuriyarkutty.

There was no guard or watchman for the Thekkady area. The Watchman and Guard posted for Orukombankutty area were never to be seen there, as they did not stay there due to the absence of accommodation and other facilities. Considerable poaching of animals was reported from Thekkady and Orukombankutty area.

There were also two Wildlife Guides stationed at Thunakadavu during the study period.

WILDLIFE MANAGEMENT

There is no management system as such. The vaccination of cattle against Rinderpest and the provision of 16 saltlicks—10 during 1974-75 and the rest in 1976 are perhaps the only attempts at management.

Existing threats to Wildlife in the area

(1) *The proposed Kuriyarkutty Project*:

The project envisages the construction of three dams; one in Karapara river, one in Pulickalar and a third one in Kuriyarkutty river. It is aimed at irrigating 43,000 acres of land in Chittoor area. The project when completed will have three power house stations with an initial plant capacity of 82 MW. in total (Table 6).

TABLE 6

DETAILS OF THE PROJECT

	Karapara	Pulickalar	Kuriyarkutty
Catchment area	18.48 Sq. Ml.	6.24 Sq. Ml.	49.50 Sq. Ml
Water spread area full Reservoir level	8.75 acres	1200 acres	2950 acres
Full Reservoir level	+3087′	+2425′	+1791′
Type of dam	Masonry gravity	Masonry gravity	Masonry earch

Only Kuriyarkutty dam will come within the limits of the Sanctuary.

Its waterspread area covers most of the forests in Thellickal/Kachithodu area. This area is very rich in Wildilife; pug marks of two tigers were seen here. Though the other two dams would be coming up only in Nelliampathy areas, outside of sanctuary limit, the impact of them on the ecology of the area would be severe, since they are very close to the sanctuary.

Parambikulam already has three dams. Parambikulam, Thunakadavu and Perivarapallam. Though no authentic data are available to show whether the wildlife has diminished after the construction of these three dams, enquiries with local people show that the wildlife population has gone down tremendously, especially the population of elephant and Gaur, owing to the construction of these dams. Theoretically, the population, which might have suffered very greatly during the construction of these dams, might be in the process of rebuilding. Therefore, a new strain on the ecology of the area will certainly be detrimental to the interest of the remaining wildlife.

Even if the whole Kuriarkutty project consisting of three dams cannot be called off, it is suggested here that the whole project should be reviewed and the possibility of calling off Kuriyarkutty dam which will be inside the sanctuary limits be considered.

(2) *Extraction of Bamboo*:

The common bamboo is *Bambusa arundinaceae* which flowers gregariously at long intervals. Licence is issued for the extraction of bamboo; the general norms which are laid for the felling and removal of Bamboo are:

1. "No clump shall be clearfelled except those that have flowered, in which case they shall be clearfelled only during the year following the flowering so that there may be enough time for seed fall and subsequent germination".
2. "The total number of culms removed from a single clump shall not exceed the number of immature shoots present".
3. "The cutting shall be distributed as far as possible over the whole clump.
4. "Culms should be cut as low as possible, and the cut shall always be made above

the node so as to prevent rainwater collecting in the stumps."

Apart from the fact that these norms are ignored, the magnitude of disturbance caused to the Wildlife is very severe. Movements of workers in the sanctum-sanctorum of the sanctuary and movements of trucks on and off, have detrimental effect on wildlife. Whether the workers poach is anybody's guess.

(3) *Minor forest produce*:

Under this apparently deceptive heading falls cane, reeds, cardamom, honey and wax extraction. Cardamom is extracted mainly from the Sholayar area. The right of collection of the produce is sold in auction to private parties for a year or two. A number of people are employed for the collection, while the removal of reeds, canes, etc., speeds up the habitat shrinkage, the movement of people through the sanctuary scares away the wild animals. Normally the workers live in temporary sheds inside the forest for days together. Their activities form a continuous disturbance to wildlife.

(4) *Taungya system*:

The taungya system was introduced to Kerala in 1922, about 60 years after its origin in Burma. In Parambikulam, all plantations after 1932 were raised under the taungya system. After clearfelling an area, it is planted with seedlings of desired plantation trees and is leased out for cultivation (here it is Tapioca). The apparent advantage of this cultivation is that it prevents weed growth and also offers shade to the seedlings. The ecological disadvantages of this system are:

1. When an area is clearfelled and the logs transported, a major portion of what is due to the soil is lost, decomposition of the plant material not being facilitated.
2. The soil mounts, which are made for planting the tapioca, are the worst affected by erosion during rain.
3. By tapioca cultivation, a major portion of the nutrient of the soil is lost in the form of tapioca tubers.
4. When the crop is harvested, the tubers are pulled out from the soil—the soil becomes very loose and hence vulnerable to erosion by rain.
5. The resultant soil deprived of its vitality, could probably impair the growth of the seedlings.
6. The tapioca plant, which grows fast, often overshadows the seedlings and obstructs light. How far it affects the growth of the seedlings is not known.

The probable effects of taungya on wildlife are:

1. The increased human activities on the taungya land scare away the wild animals.
2. On the protext of crop protection the taungyadars often keep guns which ultimately lead to ruthless poaching of animals.
3. Tapioca tubers attract rodents in large numbers and provide additional food to them. This abundance of food might lead to their rapid multiplication. When the tapioca is harvested, and the additional food is no more available, these rodents might migrate to the neighbouring areas —probably to villages in search of food. In other words, the population which grew beyond the optimum level due to the addition of food would be expelled as a result of competition from the area when that additional food was no longer available. This population probably migrated to the adjacent villages thereby causing damage to village crops.

4. Wild pigs are also attracted by the tubers of tapioca. The piglets which are born while the tapioca is available, are trained to feed on these and are denied the opportunity of being trained to feed on and search for natural food. This could probably make the piglets less competent to live in the natural condition later on. All these are probable impacts of the taungya system and have to be studied in detail.

Notwithstanding its ecological impacts, the most severe and at the same time, the most obvious impact of taungya on wildlife is the indiscriminate poaching of wild animals by the taungyadars. Therefore, even if with all the potential ecological dangers it is decided to continue the taungya system, it is suggested here that in order to decrease the poaching activities the forest department should themselves undertake the cultivation instead of leasing it out to private parties.

However, stopping this system has a lot of social problems as tapioca is one of the major food items of the poor in Kerala. Therefore, a study on all aspects of this system has to be made.

(5) *Tribal settlement*:

There are four types of tribals in the Parambikulam sanctuary area: Mudukas, Kadas, Mulssers and Mulmalssers. They occupy different areas inside the sanctuary. Mulssers and Mulmalssers are at Katchithodu and Sungam; Kadas at Kuriyarkutty-Parambikulam area and Mudukas opposite to Parambikulam lake; altogether there are about 300 families. During the time of observation, the tribals at Katchithodu were seen collecting bamboo rice. Ground under the bamboo clump was cleared and the rice that fell was collected. Tribals are given land for cultivation at Katchithodu area. This practice has a built-in danger to wildlife. The area is surrounded bv forest where wildilfe is abundant. Animals often cross the field to the forest on the other side. Therefore, the tribals have to scare away the animals from their crop. Trapping of smaller game like junglefowl is common among these people. It was told that 200 acres of land have been allocated for the tribals for settlement and cultivation. The land selected for this is at Sungam, where wild animals are often seen and this is a severe threat to the wildlife of the area.

(6) *Cattle grazing*:

Cattle are not abundant at Sungam range, but in Parambikulam area they are. Reduction of their number at Parambikulam is necessary.

(7) *Felling*:

Both clearfelling and selection felling were not observed in Parambikulam area during the period of study. But in Sholayar, areas were being marked for selection felling. It is suggested here that no forestry operation should be undertaken in areas lying close to Orukombankutty and Karimalagopuram area of Parambikulam where Liontailed Macaques are common.

(8) *Elephant capture*:

Elephant capture has been going on for years in this area, but has been stopped since 1975. The pits prepared during the operation have been left unfilled and cause accidents to wild animals occasionally. It was reported that once a gaur calf fell into one of the pits, and another time an adult bull. It is suggested that pit capture of elephants should not be restarted and that the pits left by the former operations should be filled.

(9) *Fire*:

Evidences of fire were seen at many places, including areas very close to evergreen forests —areas adjacent to the small patch of evergreen forest on the side of Vengoli peak. Several places on the way to Karimalagopuram, many places at Anapadi were found burnt. Fire inside the teak plantations was also rampant. None was natural, but man-made. Man-made fire, unless under control, is very destructive to wildilfe and to the general ecology of the area.

(10) *Stray dogs*:

At Thunakadavu, Parambikulam, Kuriyarkutty and Sungam areas stray dogs are abundant. At Thunakadavu, a dog was seen chasing a spotted deer. There is also the danger of transmitting rabies to wild animals.

(11) *Man and Wild Dog kills*:

When a sambar is killed by the wild dogs, the dogs are often chased away and the prey is collected by the local people. On 23rd April, 1976, at Thellickal, very close to the labourers' quarters of the Electricity Board, one Sambar was found killed by wild dogs. It had three small injuries. One on the neck, one below the left eye and another one on the chest. The animal was killed near the Thellickal river and pulled towards the river bed, but the wild dogs were chased away and the kill was collected by the people. I understood that this is the regular practice here. This means the dogs will make an additional kill and in the long run, this type of poaching by man of the wild dogs kills is bound to affect the balance between the wild dog and its prey.

(12) *Poaching*:

No poaching was seen during the period of observation, but gun shots were heard many times from the Tapioca plantation area. It was learned from reliable people that the tapioca contractors indulge in poaching quite often.

Tourism

The presence of representative peninsular Indian species and the possibility of viewing some of them easily should attract tourists. Endangered species like Nilgiri Tahr and Lion-tailed macaque could be seen within an hour's walk from the main road at Vengoli peak. The giant teak known as Kannymarathekku (50+ metres high and 6 metres girth) which is at least 300 years old, and the Woods Grave—the grave of Mr. Hugh Woods, who was a working plan officer in the 1900's—add to the tourist attraction. Boating facilities though not availiable at present, could be an additional attraction to tourists.

Accommodation

The only accommodation available inside the sanctuary is at Parambikulam where the P.W.D. of Tamil Nadu has a Rest House with five suites. At present a small bungalow with two suites has come up at Thunakadavu. Tourists could also stay at Topslip area, half an hour drive from Thunakkadavu.

Conveyance

There are no transport facilities in this area. A jeep has been allocated for tourists but would never become available.

RECOMMENDATIONS

1. A thorough analysis of the Kuriyarkutty project by a combined team of Wildlife Biologists and the concerned engineers, is necessary to consider reducing the submergible areas at least inside the sanctuary limits.

2. Stop extraction of bamboos from the sanctuary area.
3. Discourage collection of minor forest products from the sanctuary limits.
4. If taungya system cannot be stopped, it should be undertaken by the forest department to reduce poaching.
5. Discourage the tribals from settling inside the sanctuary area; if this is not possible, remove and rehabilitate them outside the sanctuary.
6. Discourage the granting of land to the tribals for cultivation in the interior of the forest.
7. Reduce the cattle population in Parambikulam while maintaining the present population of cattle in the Sungam area.
8. Discourage selection felling in Sholayar area.
9. Elephant-capture pits should be covered to avoid accidents to other wildlife.
10. Fire lines of standard size should be put and more watchmen should be employed for fire-watching.
11. Stray dogs should be removed from the sanctuary.
12. Stringent measures should be taken against stealing of wild dog kills.
13. Thuthanpara and Karapara beats on the west and the forests lying east of Chalakudy river and north of Vazhachal-Valpara road which include part of the Vazhachal range and part of Anakkayam beat, Sholayar beat and Chandanathodu beat of the Sholayar range on the south should be included in the sanctuary area. Forestry operations or any other disturbance to the habitat in the Thuthanpara and Karapara beat might destroy the population of Liontailed Macaque in the Orukombankutty area. Pressure to the habitat and population of this macaque from various estates in this area is considerable. Thuthanpara and Karapara beats, if preserved, would act as a buffer zone to the habitat of Macaques in the Orukombankutty area.

   Liontailed macaques were observed at Sholayar and Chandanathodu beats of the Sholayar range and also at Kuriyarkutty area of Parambikulam Sanctuary. The forests of Kuriyarkutty and Orukombankutty are separated by Teak plantations. The only possible connection is through the Karapara river valley (I observed one troop here). The other possible connection is perhaps through the narrow isthmus-like projection through teak plantations of Orukombankutty forests where the Parambikulam river and Sholayar river meet. Through this forest connection, the macaques could move to the Sholayar area. Troops in the Kuriyarkutty area will be isolated if forests in the Sholayer-Chandanathodu beats are destroyed. Therefore, Sholayar and Chandanathodu beats and the forests west of it up to Chalakudy river, if included in the Sanctuary and protection offered, the troops of these areas and the troops of Kuriyarkutty and Orukombankutty could mix, interbreed and form a healthy population.

I feel that this sanctuary should not be opened for tourism, but should be preserved for research, and hence no suggestions are made here for the improvement of tourist facilities.

APPENDIX I

A SYSTEMATIC LIST OF THE BIRDS SEEN/HEARD IN PARAMBIKULAM/SHOLAYAR AREA

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1. Little Cormorant, *Phalacrocorax niger.*
2. Cattle Egret, *Bubulcus ibis.*
3. Night Heron, *Nycticorax nycticorax.*
4. Blackwinged Kite, *Elanus caeruleus.*
5. Common Pariah Kite, *Milvus migrans.*
6. Brahminy Kite, *Haliastur indus.*
7. Shikra, *Accipiter badius.*
8. Indian Crested Hawk-Eagle, *Spizaetus cirrhatus.*
9. Black Eagle, *Ictinaetus malayensis.*
10. Greyheaded Fishing Eagle, *Icthyophaga ichthyaetus.*
11. Crested Serpent Eagle, *Spilornis cheela.*
12. Indian Kestrel, *Falco tinnunculus.*
13. Bush Quail, *Perdicula* sp. ?
14. Grey Junglefowl, *Gallus sonneratii.*
15. Whitebreasted Waterhen, *Amaurornis phoenicurus.*
16. Redwattled Lapwing, *Vanellus indicus.*
17. Fantail Snipe, *Capella gallinago.*
18. Common Green Pigeon, *Treron phoenicoptera.*
19. Grayfronted Green Pigeon, *Treron pompadora.*
20. Jerdon's Imperial Pigeon, *Ducula badia.*
21. Nilgiri Wood Pigeon, *Columba elphinstonii.*
22. Indian Spotted Dove, *Streptopelia chinensis.*
23. Indian Emerald Dove, *Chalcophaps indica*
24. Blossomheaded Parakeet, *Psittacula cyanocephala.*
25. Bluewinged Parakeet, *Psittacula columboides.*
26. Malabar Lorikeet, *Loriculus vernalis.*
27. Common Hawk-Cuckoo, *Cuculus varius.*
28. Small Greenbilled Malkoha, *Rhopodytes viridirostris.*
29. Crow-Pheasant, *Centropus sinensis.*
30. Collared Scops Owl, *Otus bakkamoena.*
31. Brown Fish Owl, *Bubo zeylonensis.*
32. Brown Wood Owl, *Strix leptogrammica.*
33. Malabar Jungle Owlet, *Glaucidium radiatum.*
34. Hawk-Owl, *Ninox scutulata.*
35. Spotted Owlet, *Athene brama.*
36. Ceylon Frogmouth, *Batrachostomus moniliger.*
37. Indian Jungle Nightjar, *Caprimulgus indicus.*
38. Common Indian Nightjar, *Caprimulgus asiaticus.*
39. Large Brownthroated Spinetail Swift, *Chaetura gigantea.*
40. Malabar Trogon, *Harpactes fasciatus.*
41. Common Kingfisher, *Alcedo athis.*
42. Brownheaded Storkbilled Kingfisher, *Pelargopsis capensis.*
43. Whitebreasted Kingfisher, *Halcyon smyrnensis.*
44. Chestnutheaded Bee-eater, *Merops leschenaulti.*
45. Bluebearded Bee-eater, *Nyctyornis athertoni.*
46. Indian Roller, *Coracias benghalensis.*
47. Broadbilled Roller, *Eurystomus orientalis.*
48. Hoopoe, *Upupa epops.*
49. Great Indian Hornbill, *Buceros bicornis.*
50. Small Green Barbet, *Megalaima viridis.*
51. Coppersmith, *Megalaima haemacephala.*
52. Speckled Piculet, *Picumnus innominatus.*
53. Rufous Woodpecker, *Micropternus brachyurus.*
54. Small Yellownaped Woodpecker, *Picus chlorolophus.*
55. Goldenbacked woodpecker, *Dinopium benghalense.*
56. Great Black Woodpecker, *Dryocopus javensis.*
57. Yellowfronted Pied Woodpecker, *Dendrocopos mahrattensis.*
58. Pigmy Woodpecker, *Dendrocopos nanus.*
59. Heartspotted Woodpecker, *Hemicircus canente.*
60. Indian Pitta, *Pitta brachyura.*
61. Dusky Crag Martin, *Hirundo concolor.*
62. Eastern Swallow, *Hirundo rustica.*
63. Redrumped Swallow, *Hirundo daurica.*
64. Brown Shrike, *Lanius cristatus.*
65. Blackheaded Oriole, *Oriolus xanthornus.*
66. Black Drongo, *Dicrurus adsimilis.*
67. Whitebellied Drongo, *Dicrurus caerulescens.*
68. Bronzed Drongo, *Dicrurus aeneus.*
69. Haircrested Drongo, *Dicrurus hottentottus.*
70. Large Racket-tailed Drongo, *Dicrurus paradiseus.*
71. Greyheaded Myna, *Sturnus malabaricus.*
72. Common Myna, *Acridotheres tristis.*
73. Grackle, *Gracula religiosa.*
74. Tree Pie, *Dendrocitta vagabunda.*
75. Southern Tree Pie, *Dendrocitta leucogastra.*
76. House Crow, *Corvus splendens.*
77. Indian Jungle Crow, *Corvus macrorhynchos.*
78. Pied Flycatcher-Shrike, *Hemipus picatus.*

79. Common Wood Shrike, *Tephrodornis pondicerianus.*
80. Blackheaded Cuckoo-Shrike, *Coracina melanoptera.*
81. Orange Minivct, *Pericrocotus flammeus.*
82. Small Minivet, *Pericrocotus cinnamomeus.*
83. Iora, *Aegithina tiphia.*
84. Goldenfronted Chloropsis, *Chloropsis aurifrons.*
85. Fairy Bluebird, *Irena puella.*
86. Rubythroated Bulbul, *Pycnonotus melanicterus gularis.*
87. Redwhiskered Bulbul, *Pycnonotus jocosus.*
88. Redvented Bulbul, *Pycnonotus cafer.*
89. Yellowbrowed Bulbul, *Hypsipetes indicus.*
90. Black Bulbul, *Hypsipetes madagascariensis.*
91. Spotted Babbler *Pellorneum ruficeps.*
92. Scimitar Babbler, *Pomatorhinus schisticeps.*
93. Blackheaded Babbler, *Rhopocichla atriceps.*
94. Rufous Babbler, *Turdoides subrufus.*
95. Jungle Babbler, *Turdoides striatus.*
96. Wynaad Laughing Thrush, *Garrulax delesserti.*
97. Quaker Babbler, *Alcippe poioicephala.*
98. Brown Flycatcher, *Muscicapa latirostris.*
99. Rufous Flycatcher *Muscicapa ruficauda.*
100. Tickell's Blue Flycatcher, *Muscicapa tickelliae.*
101. Greyheaded Flycatcher, *Culicicapa ceylonensis.*
102. Paradise Flycatcher, *Terpsiphone paradisi.*
103. Blacknaped Blue Flycatcher, *Monarcha azurea.*
104. Longtail Warbler, *Prinia hodgsonii.*
105. Plain Longtail Warbler, *Prinia subflava.*
106. Tailor Bird, *Orthotomus sutorius.*
107. Thickbilled Warbler, *Phragmaticola aedon.*
108. Blyth's Reed Warbler, *Acrocephalus dumetorum.*
109. Dull Green Leaf Warbler, *Phylloscopus trochiloides.*
110. Leaf Warbler, *Phylloscopus* sp.?
111. Magpie Robin, *Copsychus saularis.*
112. Malabar Whistling Thrush, *Myiophoneus horsfieldii.*
113. Whitethroated Ground Thrush, *Zoothera citrina cyanotus.*
114. Indian Grey Tit. *Parus major.*
115. Yellowcheeked Tit, *Parus xanthogenys.*
116. Velvetfronted Nuthatch, *Sitta frontalis.*
117. Paddyfield Pipit, *Anthus novaeseelandiae.*
118. Forest Wagtail, *Motacilla indica*
119. Grey Wagtail, *Motacilla caspica.*
120. White Wagtail, *Motacilla alba.*
121. Large Pied Wagtail, *Motacilla maderaspatensis.*
122. Thickbilled Flowerpecker, *Dicaeum agile.*
123. Tickell's Flowerpecker, *Dicaeum erythrorhynchos.*
124. Indian Purplerumped Sunbird, *Nectarinia zeylonica.*
125. Small Sunbird, *Nectarinia minima.*
126. Purple Sunbird, *Nectarinia asiatica.*
127. Little Spiderhunter, *Arachnothera longirostris.*
128. White-eye, *Zosterops palpebrosa.*
129. House Sparrow, *Passer domesticus.*
130. Whitethroated Munia, *Lonchura malabarica.*
131. Rufousbellied Munia, *Lonchura kelaarti.*
132. Spotted Munia, *Lonchura punctulata.*
133. Blackheaded Munia, *Lonchura malacca.*

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I am grateful to the Bombay Natural History Society for sponsoring the project and to its Curator, Mr. J. C. Daniel, for his guidance and encouragement. I am grateful to the World Wildlife Fund-India for financing the study, and to Mrs. D. S. Variava, Administrator, World Wildlife Fund-India, for taking a keen interest in the successful completion of the project.

I record my sincere thanks to Mr. K. K. Nair, Chief Conservator of Forests (Development), Kerala, for permitting me to work inside the forests. The co-operation of the field staff of the Forest Department in Parambikulam and Sholayar is gratefully acknowledged.

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NEW DESCRIPTIONS

A NEW SPECIES OF *IMPATIENS* LINN. (BALSAMINACEAE) FROM SOUTH INDIA[1]

M. Chandrabose[2]

(*With nine text-figures*)

Impatiens chandrasekharanii sp. nov.

Impatiens modesta Wt. affinis tamen differens foliis palmatim profunde lobatis, lobis denuo in lobulis lobatis, palmatim 3-5—nervatis; calcare labii cylindrico leviter incurvato; vexillo suborbiculari, latiori quam longo, apice indentato, lobo membranaceo ad centrum porcato.

Herba scapigera; caudex 1—1.8 × 0.5—0.8 cm, roseus, elliptico-oblongus, tuberosus, laevis, fibrillosus. Folia radicalia; lamina 2—8.5 cm diam., sub-orbicularis, palmatim 3-9-lobata; lobi 1.5—5×0.3—1.5 cm, oblongo—obovati vel ovati, membranacei, glabri (praeter pilos paucos super nervos supra), lobulis divisi; lobuli emarginati, apice breviter mucronati, basi attenuati, palmatim 3—5-nervati, nervis roseis; petioli 1—6 cm longi, striis pallido-viridis, graciles, glabri. Flores 0.8—1.2 cm diam., albi, roseosuffusi, pauci, racemosi; scapus 3—20 cm longus, gracilis, erectus, glaber; pedicelli 0.7—2 cm longi, graciles, glabri; bracteae 2—2.5 × 1.2 mm, virides, ovato-oblongi, subobtusi, glabri. Sepala 3; lateralia 2, utrumque ± 2 × 1.2 mm, pallido-viride, punctis roseuis, ovato-oblongum, subacutum, glaber; posterior vero ± 3 mm longum, album, late ovatum, concavum, apice subacutum, ad basim calcaratum; calcar ± 3 mm longum, album, cylindricum, leviter incurvatum. Petala 3, alba, roseo-suffusa, vexillum 2—3 × 4—5 mm, latior quam longum, suborbiculare, membranaceum, lobo membranaceo ad centrum porcatum, lgaber, apice indentatum; alae 2, utrumque ± 1 cm longa, glabra (praeter pilos paucos papillatos intra ad basin), 3-lobata; lobi ± 4 × 2 mm, subaequales, oblongo-obovati, obtusi. Stamina ± 2 mm longa, 5; filamenta brevia; antherae coherentes. Ovarium ± 1.5 × 1 mm, ovato-ellipticum, glaber; stigma sessile, 5-dentatum. Capsula (immatura) ± 2 × 0.5 mm, ellipsoidea, glabra. (Figs. 1-9).

Holotypus *Chandrabose 57269 A* et isotypi *Chandrabose 57269 B-N* lecti ad Akkamalai, Anamalai, Dist. Coimbatore in statu Tamil Nadu (Madras) lie 23-7-1978; holotypus positus in CAL, isotypi in MH.

Impatiens chandrasekharanii sp. nov.

Allied to *Impatiens modesta* Wt., but differs in having leaves palmately, deeply lobed, lobes again divided into lobules, palmately 3-5 nerved; spur of lip cylindric, slightly incurved; and standard petal suborbicular, broader than long, indented at apex, ridged with a membranous flap at the centre.

Scapigerous herbs; rootstock 1-1.8 × 0.5-0.8 cm, pink, elliptic-oblong, tuberous, smooth, with fibrous roots. Leaves radical; lamina 2-8.5 cm across, suborbicular in outline, palmately 3-9 lobed; lobes 1.5-5 × 0.3-1.5 cm, oblong-obovate or obovate, membranous, glabrous (except-

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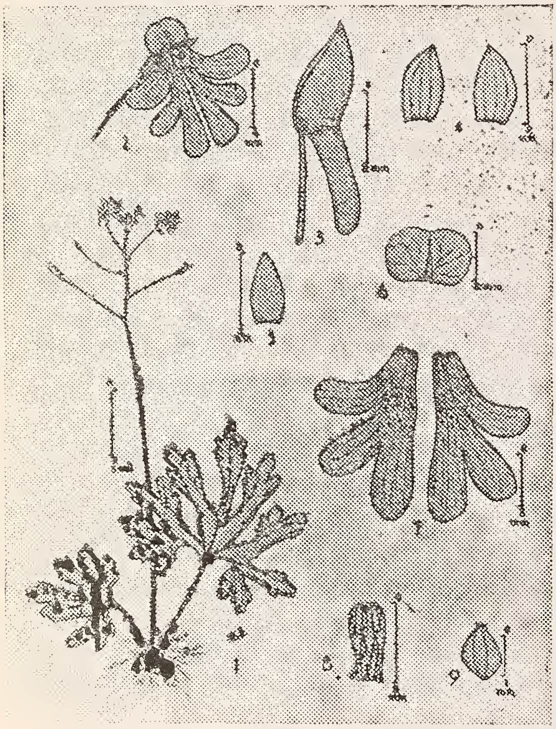
[1] Accepted October 1978.

[2] Botanical Survey of India, Coimbatore-641 002.

ing a few hairs on the nerves above), divided into lobules; lobules emarginate, with a short mucro at apex, attenuated at base, palmately 3-5 nerved, nerves pink; petioles 1-6 cm long, pale green with pink striations, slender, glabrous. Flowers 0.8—1.2 cm across, white with pink tinge, few, in racemes; scape 3-20 cm long, slander, erect, glabrous; pedicels 0.7-2 cm long, slender, glabrous; bracts 2-2.5 × 1.2 mm, green, ovate-oblong, subobtuse, glabrous. Sepals 3; laterals 2, each ± 2 × 1.2 mm, pale green with pink dots, ovate-oblong, subacute, glabrous; posterior sepal ± 3 mm long, white, broadly ovate, concave, subacute at apex, spurred at base; spur ± 3 mm long, white, cylindric, slightly incurved. Petals 3, white with pink tinge; standard petal 2-3 × 4-5 mm, broader than long, suborbicular, membranous, ridged with a membranous flap at the centre, glabrous, indented at apex; wing petals two, each ± 1 cm long, glabrous excepting a few papillate hairs at the base within, 3-lobed; lobes ± 4 × 2 mm, subequal, oblong-obovate, obtuse. Stamens ± 2 mm long, 5; filaments short; anthers cohering. Ovary ± 1.5 × 1 mm, ovate-elliptic, glabrous; stigma sessile, 5-toothed. Immature capsules ± 2 × 0.5 mm, ellipsoid, glabrous. (Figs. 1-9).



Figs. 1-9. *Impatiens chandrasekharanii* sp. nov. 1. Habit; 2. Flower; 3. Posterior sepal; 4. Lateral sepals; 5. Bract; 6. Standard petal; 7. Wing petals; 8. Androecium; 9. Gynoecium.

The holotype *Chandrabose 57269 A* (CAL) and isotypes *Chandrabose 57269 B-N* (MH) were collected in Akkamalai, Anamalai in Coimbatore District, Tamil Nadu (Madras State) on 23.7.1978.

This curious delicate species grows usually on wet tree trunks and occasionally on wet rocks in tuft of moss in the evergreen forests at an altitude of 1,700 m. This species is named in honour of Dr. N. Chandrasekharan Nair, Deputy Director, Botanical Survey of India, Coimbatore for his contribution to the taxonomy of Indian plants.

ACKNOWLEDGEMENTS

Grateful thanks are due to Dr. C. Grey-Wilson, Royal Botanic Gardens, Kew, Surrey, England working at present on the section *scaposae* of *Impatiens* Linn. for his valuable opinion on the specimen; Rev. Fr. Dr. K. M. Matthew, S.J., Rapinat Herbarium, Tiruchirapalli for rendering Latin translation; and Dr. A. N. Henry, Systematic Botanist, Botanical Survey of India, Coimbatore for help.

TWO NEW SPECIES OF SPIDER OF THE GENUS *THARPYNA* KOCH FROM INDIA (FAMILY : THOMISIDAE)[1]

B. K. Tikader[2] and Bijan Biswas

(*With six text-figures*)

INTRODUCTION

The spiders of the family Thomisidae are moderately known from Indian fauna. Stoliczka (1969), Simon (1892), Dyal (1935) described some species of Thomisidae from India, however the classical work of Pocock (1900) on Indian spiders contains no reference to this family. Recently Tikader (1960, 1971) and Tikader & Biswas (1974) recorded many known and new species of the various genera of the family.

While examining the spider collection received from West Bengal and Himachal Pradesh, we came across two new species of spiders of the genus *Tharpyna* Koch of the family Thomisidae, which are being described in this paper. The illustrations used in this paper are prepared by Shri P. W. Garde, Artist of this station.

All type specimens will in due course be deposited in the National Collection of Zoological Survey of India, Calcutta.

Genus *Tharpyna* Koch

Tharpyna Koch, 1874. *Ar. Austr.*, : 548.

Tharpyna: Simon, 1892. *Hist. Nat. Araign.*, 1 : 1015.

Tharpyna: Workman, 1896. *Malaysian spider*, 1 : 4.

Characters: Cephalothorax moderately high, convex, slightly wider in front, side nearly parallel. Eyes in two rows, both are recurved, median eyes nearer to each other than to adjacent laterals. Ocular quad longer than wide and wider behind. Crab-like appearance. Abdomen decorated and clothed with hairs.

Type-species: *Tharpyna diademata* Koch.

Distribution: Java; N. Hollandia, New Zealand, Burma, Sumatra and India.

Tharpyna indica sp. nov.

(Figs. 1-3)

General: Cephalothorax reddish brown, abdomen black with white patches. Total length 4.50 mm. Carapace 1.75 mm. long, 1.75 mm. wide; abdomen 2.30 mm. long, 2.70 mm. wide.

Cephalothorax: Nearly as long as wide, moderately high and convex, smooth and shiny, deep brown, slightly narrowing posteriorly, clothed with a few stout hairs; thoracic region slightly elevated. Eyes in two rows, both recurved. Anterior laterals larger and posterior medians smallest. Both medians nearer to each other than from the adjacent laterals. Ocular quad slightly longer than wide and wider behind. Sternum heart-shaped, pointed posteriorly, brown, clothed with fine hairs. Labium brown, longer than wide, distal end of maxillae pale and wide. Chelicerae weak reddish brown, clothed with hairs. Legs short and stout, reddish brown, coxae and the proximal end of the femora II, III & IV with pale colour.

Abdomen: Almost round slightly narrowing

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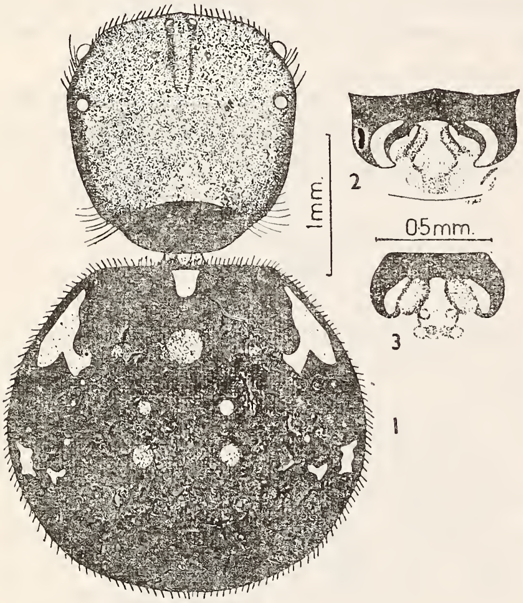
[1] Accepted May 1978.

[2] Zoological Survey of India, Western Regional Station, Poona-411 005.

posteriorly, jet black, covered with pubescence. Dorsally near the edge provided with conspicuous irregular shaped chalk white patches as in text-fig. 1. Anterior median provided with a large sigilla followed posteriorly by two pairs of sigilla. Posterior extremity also provided with small white patches and spots. Ventral side black. Two pale round spots present just posterior to the epigyne. Epigyne as in text-fig. 2. Internal genitalia as in text-fig. 3. Male unknown.



Tharpyna indica sp. nov.
1. Dorsal view of female, legs omitted; 2. Epigyne; 3. Internal genitalia.

Holotype female, *paratype* one female in spirit.

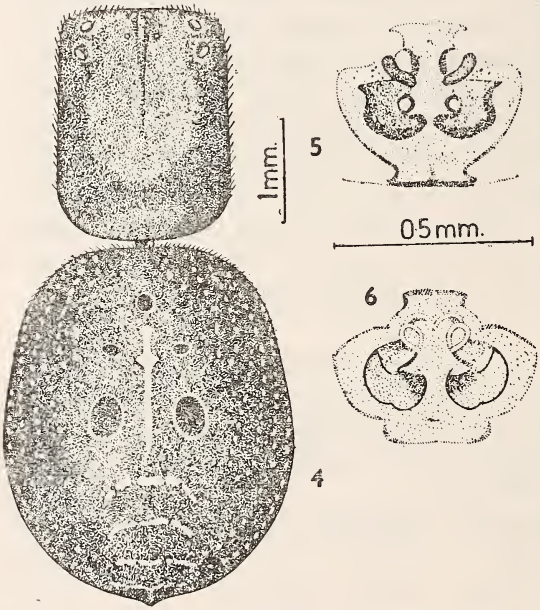
Type-locality: Choona Vhati near Sibpur Botanical Garden, Dist. Howrah, West Bengal, India. Coll. *Bijan Biswas*, 25.8.1977.

This species resemble *T. diademata* Koch but can be separated on the basis of: (i) difference in abdominal colour pattern and (ii) structural difference in Epigyne and Internal genitalia.

Tharpyna himachalensis sp. nov.
(Figs. 4-6)

General: Cephalothorax, legs reddish brown, abdomen deep-brown. Total length 5.75 mm. Carapace 2.25 mm long, 1.70 mm wide; abdomen 3.40 mm long, 2.90 mm wide.

Cephalothorax: Longer than wide, wider in front, moderately high and convex, smoothly shiny and deep reddish brown; slightly narrowing posteriorly, clothed with a few short hairs, thoracic region slightly elevated. Eyes in two rows, both recurved but posterior row more recurved than anterior row. Anterior and posterior laterals large and nearly same size, posterior medians smallest. Both medians nearer to each other than from adjacent laterals. Ocu-



Tharpyna himachalensis sp. nov.
4. Dorsal view of female, legs omitted; 5. Epigyne; 6. Internal genitalia.

lar quad slightly longer than wide and wider behind. Sternum nearly oval. slightly pointed posteriorly, brown, clothed with fine hairs. Labium and maxillae brown, longer than wide, distal end of maxillae pale and wide. Chelicerae weak, reddish-brown, clothed with hairs. Legs short and stout, reddish brown clothed with hairs and spine-like hairs.

Abdomen: Nearly elliptical, longer than wide, clothed with fine hairs and some spine-like hairs. Dorsal side decorated with pattern of dots as in text-fig. 4. Anterior median provided with a small sigilla, followed posteriorly by two pairs of sigilla, posterior pair larger than the other and all sigilla provided with deep red colour. Ventral side pale in colour. Epigyne as in text-fig. 5. Internal genitalia as in text-fig. 6. Male unknown.

Holotype female in spirit.

Type-locality: Chogaon (Tapri) Dist., Kinnour, Himachal Pradesh, India. Coll. *Dr. Arun Kumar*, 21.6.1975.

This species resembles *Tharpyna indica* but can be separated as follows: (i) Abdomen brown with pale dots all over the dorsum but in *T. indica* abdomen jet black and provided near the edges with conspicuous irregular shaped chalk-white patches. (ii) Lateral eyes large and equal but in *T. indica* anterior lateral eyes larger than the others. (iii) Epigyne and Internal genitalia structurally different.

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A NEW SPECIES OF *PELIOCOCCUS* BORCHSENIUS FROM INDIA (HOMOPTERA : PSEUDOCOCCIDAE)[1]

RAJENDRA KUMAR AVASTHI[2]
AND
SHAIKH ADAM SHAFEE

(*With fifteen text-figures*)

Genus *Peliococcus* Borchsenius

The genus *Peliococcus* was proposed by Borchsenius in 1948 with *Phenacoccus chersonensis* Kiritshenko as type species. The genus is reported for the first time from India.

Peliococcus indicus sp. nov. (figs. 1-15)

Female (fig. 1):

Mounted material broadly oval in outline, slightly more than one and a half times longer than wide (3.32 : 1.93 mm). Dorsal surface membranous with minute setae (fig. 13) and

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[1] Accepted August 1978.

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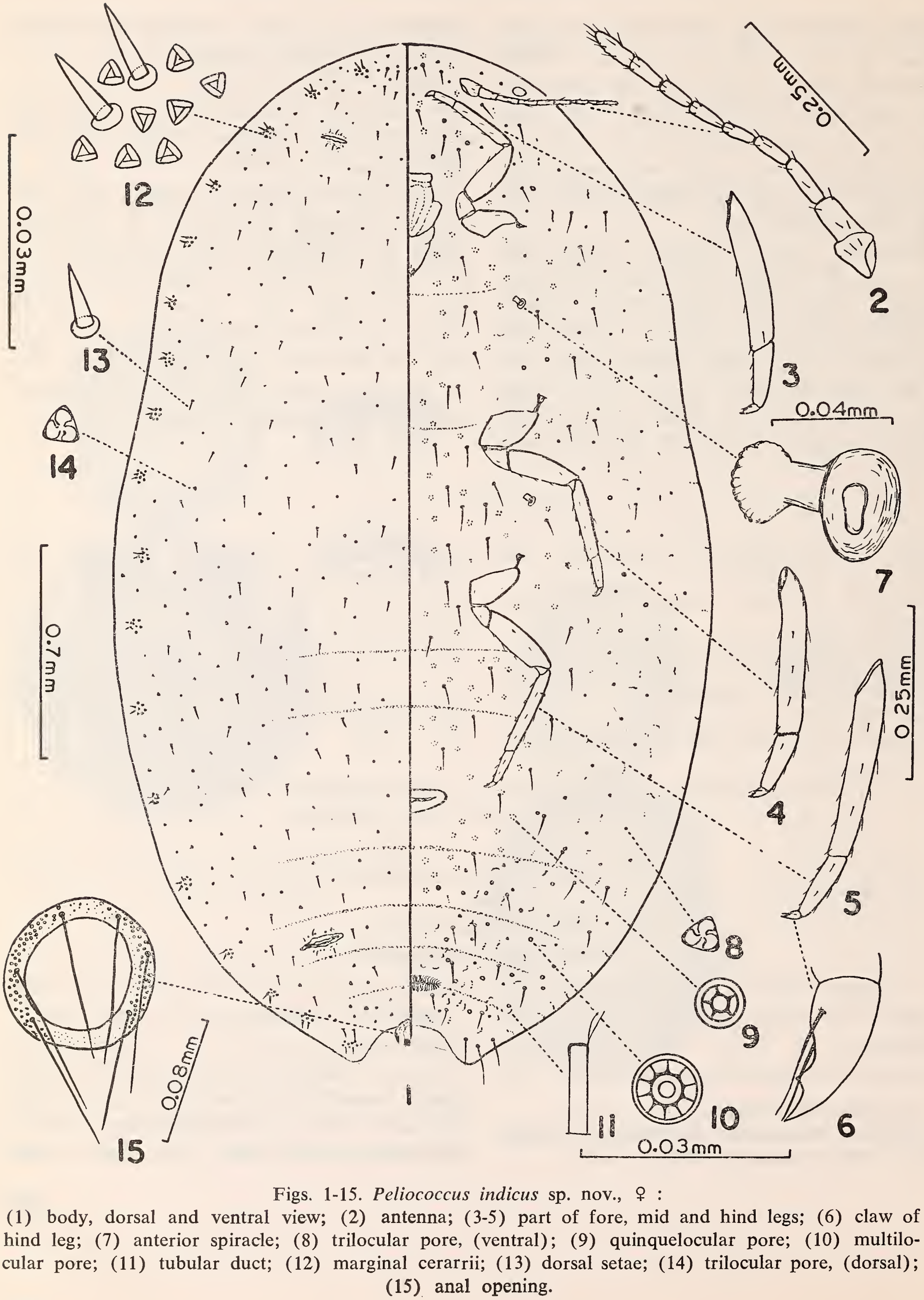
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0.03mm
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11
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Figs. 1-15. *Peliococcus indicus* sp. nov., ♀ :
(1) body, dorsal and ventral view; (2) antenna; (3-5) part of fore, mid and hind legs; (6) claw of hind leg; (7) anterior spiracle; (8) trilocular pore, (ventral); (9) quinquelocular pore; (10) multilocular pore; (11) tubular duct; (12) marginal cerarrii; (13) dorsal setae; (14) trilocular pore, (dorsal); (15) anal opening.

trilocular pores (fig. 14); margin of the body with a series of 18 pairs of cerarii, each with a pair of conical spines and a group of 7-10 trilocular pores (fig. 12); anal lobe cerarii formed with two conical spines surrounded by one or two minute setae and a group of trilocular pores; dorsal cephalic and abdominal ostioles well developed with inner membranous lips; anal ring cellular with six long setae (fig. 15).

Ventral surface membranous with sparsely distributed multilocular pores (fig. 10), small and large setae; trilocular pores arranged along the marginal and sub marginal areas of the body (fig. 8); quinquelocular pores on the mid region of the body (fig. 9); tubular ducts sparsely distributed on marginal and on posterior abdominal segments (fig. 11); posterior margin with three pairs of long setae; circulus well developed, oval in shape, between 4th & 5th abdominal segments. Labium dimerous; anterior and posterior spiracles well developed (fig. 7). Antennae 9-segmented, 0.53 mm long, inserted near the anterior margin of the cephalic region; 1st segment wider than long, segments 2-9 longer than wide (fig. 2). Legs normal; femur and tibia of fore, mid and hind legs are 0.21:0.21 mm, 0.22:0.25 mm and 0.25:0.29 mm in length respectively; claw simple with a denticle placed rather apically; claw digitules long and narrow (fig. 6).

Peliococcus indicus is more closely related to *Peliococcus plurimus* De Lotto in the margin of the body having a series of 18 pairs of cerarii, each cerarii with two conical spines and a group of trilocular pores, 9-segmented antennae, presence of cephalic and abdominal ostioles, and dentate claw. But the two species distinctly differ in the following important characters:

Peliococcus plurimus De Lotto	*Peliococcus indicus* sp. nov.
1. Claw digitule dilated at apex.	Claw digitule pointed at apex.
2. Circulus absent.	Circulus present
3. Multilocular pores confined to posterior part of abdomen on ventral surface.	Multilocular pores distributed throughout the body on ventral surface.
4. Compact clusters of numerous multilocular pores present.	Compact clusters of multilocular pores absent.

Holotype ♀, INDIA: Mysore, Bangalore, Hebbal, on *Prosopis spicigera* L., 29.vi.1968, Coll. S. Adam Shafee.

Paratypes 4 ♀ (same data as for holotype).

Holotype and Paratypes in Zoological Museum, Aligarh Muslim University, Aligarh, India.

Hayat *et al.* (1972), Shafee (1972) and Shafee *et al.* (1973) reported some species of encyrtids as parasites of *Peliococcus* sp. Host material of these parasites deposited in the Zoological Museum, Aligarh Muslim University, Aligarh has been studied and described here as a new species. The parasites reported by earlier workers are *Anagyrus nigricorpus* Shafee *et al.*, *Cheiloneurus latifrons* Hayat *et al.*, *Mashhoodia flava* Shafee, *M. indica* Shafee, and *Plagiomerus bangalorensis* Shafee *et al.*

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A NEW SPECIES AND A NEW RECORD OF THE INTERESTING GENUS *SMICROMORPHA* GIRAULT (HYMENOPTERA : CHALCIDIDAE) FROM ORIENTAL REGION[1]

T. C. NARENDRAN[2]

(*With six text-figures*)

The genus *Smicromorpha* was erected by Girault (1913) who included it under a new tribe Smicromorphini of the family Chalcididae. Girault described this genus based on the type *Smicromorpha doddi* Girault from Australia. He described two more species, *S. cadaverosa* (1914) and *S. minera* (1926) from Australia. According to Dr. Boucek *S. minera* is a misspelling for *S. minerva* (Personal communication). Since then there was no report on this genus from any part of the world. The present paper records this genus from India for the first time.

Smicromorpha keralensis sp. nov.
(Figs. 1-6)

Male: Length 4.5 mm. Head golden yellow with the eyes and ocelli black. Thorax golden yellow with pale brown patches as in Figure 4. Wings hyaline. Fore- and mid-legs golden yellow with the pretarsus pale brown. Hind coxa brownish-black; hind femur dull golden yellow with black coloration on the proximal and dorsal margin as in figure 6. Hind tarsi golden yellow with the pretarsus brown. Abdomen blackish-brown. Pubescence golden yellow.

Head (Fig. 1) a little wider than the maximum width of thorax, sparsely and shallowly punctate; interspaces between the punctures rugulose. Scrobe deep with transverse striations; apex of scrobe far away from the front ocellus, area below scrobe coarse with transverse striations. Pre-and post-orbital carinae absent (Figs. 1 & 2). Eyes large and devoid of cilia. Inter-antennal projection very small and hardly visible. The maximum diameter of median ocellus equal to that of lateral; the distance between median and lateral ocelli one-third the interocellar distance; interocular

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[1] Accepted November 1978.

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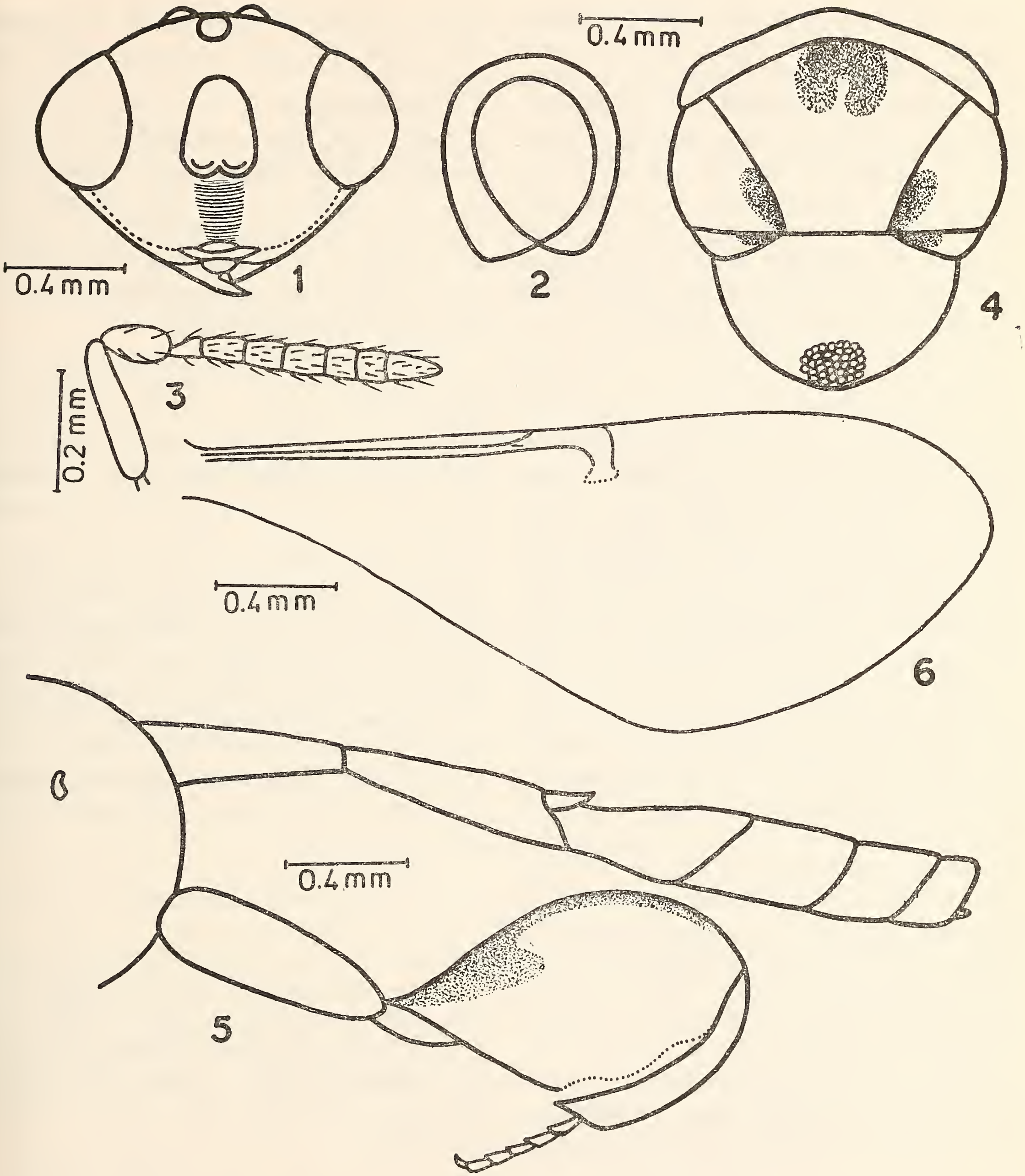
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4
3
0.2mm
0.4mm
6
0.4mm
5

Figs. 1-6. *Smicromorpha keralensis* sp. nov.

1. Head in front view; 2. head in profile; 3. antenna; 4. thorax in dorsal view (less propodeum); 5. hind leg and abdomen in lateral view (with part of propodeum); 6. fore wing.

space three and one-third times interocellar distance; width of ocellar area three-fourths interocular space; interocellar distance a little over the maximum diameter of lateral ocellus. Right mandible sickle shaped; left one short and acute. Antenna (Fig. 3) nine jointed without a ring segment, inserted a trifle over the level of lower margin of eyes; scape never reaches the front ocellus and never exceeds the upper rim of scrobe; size and shape of antennal segments as in figure 3.

Thorax (Fig. 4) moderately convex with small, shallow, reticulate and close punctures on notum; natualices complete; scutellum without a shallow median groove; metanotum with weak longitudinal costae; propodeum somewhat strongly declined posteriorly, with a shallow median groove which widens at its distal end; punctures on the propodeum simple, shallow and close, without forming definite carinae; sides of propodeum with a spiracle on each side but without teeth. Fore wing (Fig. 6) a little over two and a half times as long as wide; marginal vein a little less than four times the submarginal; stigmal shorter than the marginal; postmarginal absent. Fore and mid tibia with a single spur each. Hind coxa (Fig. 5) with reticulate shallow punctures on all sides, so rather mat; no tooth or protuberance on hind coxa. Outer side of hind femur rugose with very minute punctures; densely pubescent, outer ventral margin with a series of minute comblike teeth projecting on outer side of hind tibiae when the tibia is bent; inner basal tooth absent.

Gaster (Fig. 5) inserted far up on the propodeum just below the apex of scutellum; petiole a little shorter than the hind coxa. Segments of abdomen as in Figure 5. Segments two to five with small punctures and pubescence.

Female unknown.

Biology: Dr. Boucek informs that "the species of this group apparently are nocturnal and from the information available seem to be parasitic in the nests of ants *Oecophylla*". The specimen of *S. keralensis* was collected by me while it was flying around the nest of *Oecophylla smaragdina* Fabr.

Material. Holotype ♂ (Coll. No. C.U. 4110) on pin, INDIA: Kerala: Malappuram district, Thenhippalam 1977 (T. C. Narendran). Type retained for the time being in the Department of Zoology, University of Calicut but will eventually be deposited in a National Institution.

Comments. This is the Western-most representative of the group Smicromorphinae. It differs from all the three species reported from Australia by Girault (loc. cit.) mainly in the absence of median groove on the scutellum, in the difference of proportions of size between the segments of antenna, in the difference of proportion of fore wing veins, in the difference of coloration, and in many other features.

ACKNOWLEDGEMENTS

Thanks are due: to Dr. Z. Boucek of the Commonwealth Institute of Entomology, London, for help in the identification of this species and for various other information on the genus *Smicromorpha*.; to the Head of the Department of Zoology, University of Calicut, for facilities.

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STUDIES ON THE SCARAB BEETLES (COLEOPTERA : SCARABAEIDAE) OF NORTH EASTERN INDIA : A NEW SPECIES AND NOTES ON OTHER INDIAN SPECIES OF SUBGENUS *STRANDIUS*, GENUS *ONTHOPHAGUS*[1]

S. BISWAS[2]

(*With three text-figures*)

The genus *Onthophagus* Latreille, 1802 is one of the largest genera in the animal kingdom and contains about 1620 described species (Balthasar 1963). Division of this multitudinous species into subgenera was of practical necessity but earlier efforts to subdivide these large number of species into subgenera did not meet with much success mainly because no one person has been able to consider *Onthophagus* on a world wide basis. However, while working on Palaearctic and Oriental species, Balthasar divided the genus into a number of subgenera, and during the present study of Scarab beetles of northeastern India it has been observed that inspite of Balthasar's emphasis on extremely variable sexual characters, many of the species may easily be assigned to different subgenera.

Subgenus *Strandius* Balthasar.

Strandius Balthasar, 1935: 307. Type. *Onthophagus* (*Strandius*) *lenzi* Harold, 1874.

Medium to large species, uniformly black or elytra black with red spots or yellow with black bands; upper surface usually shining, bare or covered with minute hairs, head and pronotum with little metallic tinge.

Pronotum with a strongly raised irregularly polygonal basal disc, upper surface never granular; front angles sharp, strongly produced. Front tibiae of male rather elongated, distinctly bent, strongly broad and flat towards apex, penultimate external tooth large, placed rather at right angle, last tooth small and often directed forward. The chief characteristic of the subgenus lies in the shape of the pronotum and in the front tibiae of the male, however, in case of small male and female pronotum is rather simple.

Habits and habitats: As far as Indian species are concerned, members of this subgenus form a biologically well defined natural group. All the members are found in hills above 1000 m altitude and frequent, so far as is known, dung of herbivorous animals only.

Geographical distribution: The subgenus is known from China, Japan, Burma, Vietnam, Cambodia, India and part of Africa. In India there are three species namely *O.* (*Strandius*) *gagates* Hope, *O.* (*Strandius*) *hingstoni* Arrow and *O.* (*Strandius*) *subansiriensis* sp. nov.

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KEY TO THE INDIAN SPECIES OF THE SUBGENUS *Strandius* BALTHASAR

1. Upper surface not entirely black; parts of pronotum and elytra pale..........I. *O.* (*Strandius*) *subansiriensis* sp. nov.
— Upper surface entirely black................2.
2. Elytra shining; front angles of pronotum not hooked......................2. *O.* (*Strandius*) *gagates* Hope.
— Elytra opaque, front angles of pronotum, hooked.........................3. *O.* (*Strandius*) *hingstoni* Arrow.

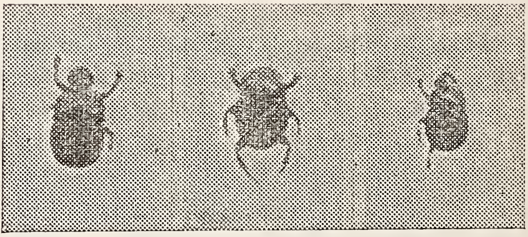
1. Onthophagus (Strandius) subansiriensis sp. nov. (Figs. 1-3).

Male major: (Holotype) length 11 mm; breadth 6 mm; head, pronotal disc and major parts of elytra black. Mouth organs, antennae except club, tarsi and a large patch beneath fore femora reddish.

Clypeus acuminate, strongly reflexed in the middle in front; disc strongly punctured, rather rugosely at sides; clypeofrontal carina weak, posterior carina obsolate, forehead strongly punctated, a little rugosely at sides, ocular lobe separated by an indistinct suture, closely punctated. Pronotum with an irregular basal disc having a strong process on each side, front and lateral margin of a disc gradually sloping, closely but unevenly punctated, punctures on disc stronger, cavity below lateral process smooth and shining; front angles acute, hind angle obsolate, base a little produced in the middle, margined; lateral margins almost straight in front, sinuate behind.

Elytra moderately strongly striate, striae sparsely covered with feeble punctuations, intervals rather closely covered with setigerous punctuations. Metasternal shield very feebly punctated in the middle, rather feebly at sides; sides of metasternum closely punctated anteriorly and covered with long hairs. Front tibiae broad at apex, provided with four external teeth, penultimate tooth largest, last one directed forward, a little obliquely placed.

Female: (Allotype) length 10.5 mm; breadth 7.0 mm; broadly oval, moderately convex. Head rounded, clypeal margin feebly reflexed in the middle in front, clypeal disc strongly and rugosely punctured, clypeofrontal carina strong, curved, posterior carina strong, straight, forehead closely and strongly but not rugosely punctured, vertex feebly punctured. Pronotum completely margined, front angle sharp, hind angle obsolate, base gently rounded, a little produced in the middle; pronotal disc less strongly defined and lateral process represented by a tubercle. Fore tibiae short, external teeth sub-equal and placed at equal distance from each other. Pygidium moderately strongly punctured.



Figs. 1-3. *Onthophagus* (*Strandius*) *subansiriensis* sp. nov.
1. Male major; 2. Female; 3. Male minor.

Male minor: (Paratype) length 9.5 mm; breadth 5.5 mm. Male minor resembling female excepting cephalic carinae, external teeth on front tibiae and 6th ventral sternite which are as in male major.

Type: Holotype ♂ major; INDIA: Arunachal Pradesh: Nacho. collected from cattle-dung. 28.xi.1974. J. M. Julka, Regd. No. A1/4391. Paratypes 1 ♀. 1 ♂ (including allotype), data same as for holotype. Deposited at present in the collection of Eastern Regional Station, Zoological Survey of India, Shillong.

Remarks: The species may easily be separated from other related species by (i) pale markings on pronotum and elytra, (ii) strong punctures on pronotum and characteristic pronotal process, and (iii) elytra covered with minute pale setae.

2. **Onthophagus (Strandius) gagates** Hope

Onthophagus gagates Hope, 1831, Gray's Zool. Misc. 22.

Onthophagus gagates: Arrow, 1931. Fauna Brit. India, Lamell., 3:378.

Onthophagus (*Strandius*) *gagates*: Balthasar, 1963. Monogr. Scarab. Aphod. palaearkt. orient., 2: 381.

Material examined: India: Meghalaya: Khasi hills, 5 ♂♂, 4 ♀♀, 30.v.1972, 1 ♀, 18.vi.1965, 1 ♀, 9.v.1965. 1♀, 30.vi.1970. 1 ♂, 13.ix.1971, 1 ♀, 28.iv.1971. 2 ♂♂, 1 ♀, 26.iv.1972, 1 ♂, 24.x.1967. coll. S. Biswas. Arunachal Pradesh: Subansiri: 1 ♂, 1 ♀, 28.xi.1974. coll. J. M. Julka.

Habits: This is a hill dwelling species, found only in the dung of herbivorous animal. Primarily a forest dweller but sometimes occurs in cleared areas near forests. It has not been collected below 1000 m altitude from Meghalaya.

Distribution: The species has been recorded in India from Himachal Pradesh (Simla Hills *c* 2500 m), Uttar Pradesh (Ranikhet, Muktesar, Chakrata, Mussoorie), Assam (Haflong), Manipur, Meghalaya (Umtyngar, Mawphlong, Shillong, Mawsynram, Dempep), Arunachal Pradesh (Subansiri dist.) and from Nepal.

3. **Onthophagus (Strandius) hingstoni** Arrow, 1931.

Onthophagus hingstoni Arrow, 1931. Fauna Brit. India, Lamell., 3: 378.

Onthophagus strandius hingstoni: Balthasar, 1963. Mon. der Scarab. und. Aphod. der palaearkt. und. orient. 2: 381.

The species has only been recorded from Sikkim at about 2000-3000 m altitude. So far it has not been collected from any other states of N. E. India.

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REVIEWS

1. THE TIGER : The Story of the Indian Tiger. By Kailash Sankhala. pp. 220 (23.5 × 16 cm) with 22 colour and 8 monochrome plates and numerous sketches. London, 1978. Collins. Price Rs. 60.00

Biographies leave one with a slight sense of embarrassment at the subtle or blatantly catalogued virtues. This book is a biography of the tiger, and of course in a sense, of the author too. The tiger has had many biographers, such has been its fascination. Some have looked at it over the sights of a rifle, some have looked at it through the lens of a camera, and a few with the dispassionate eye of a scientist. Those who see it through the sights of a gun often see a thing of evil, those who see it through the lens of a camera see a thing of beauty and the scientist sees a magnificent animal in tune with its environment. Mr. Sankhala has had a multiple view and unfortunately, often takes an abrasive look at those who had viewed the tiger before him.

The book is in two sections, the first six chapters describe the tiger and its environment, animate and inanimate. The seven chapters in the second section describe the tiger in relation to man.

The chapters in the first section are an overall review of the ecology of the tiger. Repetition of known facts is unavoidable in such an approach particularly when the animal considered is the tiger whose natural history has been the subject of attention for over a Century. It is to Mr. Sankhala's credit that he is, inspite of this handicap, able to present some excellent natural history notes.

Some of the remarks on other inhabitants of tigerland are however questionable. For instance statements such as langur babies are looked after by all the adults of a troop or that elephants cannot negotiate steep slopes or that the Egyptian or Scavenger Vulture, which is a habitual feeder on human excreta, is cleaner than other vultures and does not deserve the name Scavenger. These are but minor blemishes in a well written book.

The second section describes the inter-relationship of the tiger and man through the ages and the author makes no bones about where his sympathies lie. In the ardour of his empathy for the tiger, Mr. Sankhala is more than a little unfair to Jim Corbett, whose name has been, and continues to be, linked with the tiger in India. Corbett made it explicit in his books that what he described were abnormal tigers and his sympathy for the animal is evident in his writings.

Reading Corbett's limpid prose, the feeling one receives is of the deep love he had for the country and its people. He is remembered more for this love than for anything else.

The book ends with a description of the Conservation movement which saved the tiger, a movement to which many people, and many organisations, both local and international, contributed.

A very readable book inspite of its dogmatic approach. The plates are excellent. The pen and ink sketches are uniformally good and the chart with the sketches of animals of tigerland even has a touch of 'Paul Barruel' in its composition.

J. C. DANIEL

2. FIELD GUIDE TO THE BIRDS OF THE EASTERN HIMALAYAS. By Sálim Ali. pp. xvi + 263 (11.8 × 18 cm). With 37 coloured plates. Delhi, 1977. Oxford University Press. Price Rs. 80.00.

Dr. Sálim Ali's latest book is most welcome as an addition to the field guides to birds. It relates to an area of immense ornithological interest, covering eastern Nepal, Darjeeling district of West Bengal, Sikkim, Bhutan and Arunachal Pradesh. Except for the western part, the birds of the area are imperfectly known, and that too only through stray reports.

A concise introduction gives a brief general account of the physiography and ecology of the area, followed by short descriptions of 536 birds and 37 plates depicting 366 birds in colour. Each bird has been introduced with its common English name, zoological name, and an approximate idea of its size, followed by short accounts of its field characters, status, habitats, etc. in about 15-20 lines of text.

As in all books by Dr. Sálim Ali, the text is superbly written and will surely prove to be immensely helpful to the users of this guide. However, I would like to take this opportunity to provide some additional information here. The Bearded Vulture (p. 10, no. 24) occurs up to at least 4700 m. The Spotted winged Stare (p. 104, no. 192) is frequently found in winter at as low as *c* 120 m. The Himalayan Tree Pie (p. 109, no. 205) occasionally goes up to *c* 3200 m, even in winter. The zoological name of the Blacknaped Flycatcher (p. 171, no. 346) should be *Hypothymis azurea* (Boddaert), and that of the Black Tit (p. 219, no. 460) *Parus rufonuchalis* Blyth, the common English name for *P. rubidiventris* Blyth being the Rufousbellied Tit.

The chief weakness of this very useful field guide lies in the colour reproduction of the plates (I say 'reproduction' because I have had occasion to see some of the original paintings which were skilfully done). The faulty colour renderings may be grouped as follows:

1. Crimson and scarlet printed as chestnut, chestnut-brown, brownish red, pinkish or some other reddish colour: A very large number of figures, e.g., those of woodpeckers [pls. 9, 10, 18 (fig. 9), 35 (fig. 6)].
2. Claret-maroon printed as dark brown (pl. 6, fig. 7), and rufous also as dark brown (pl. 6, fig. 10) so that barrings on the tail have become inconspicuous.
3. Greyish brown printed as bluish grey (p. 32, fig. 7).
4. Metallic purple printed as cobalt blue (pl. 11, fig. 2); glossy jet black, slate-black, and metallic bronze-green and blue as deep blue (pl. 13).
5. Slate-grey or ashy printed as bluish grey [pls. 12, 30 (fig. 1)].
6. Ashy grey printed as purplish grey (pl. 26, fig. 12).
7. Blue-black printed with unnecessary greenish patches (pl. 26, fig. 2).
8. Black with unnecessary brownish patches [pls. 18, 36 (figs. 1, 2)].
9. Black printed as dark brown (pl. 2, figs. 6, 7).
10. Shade of green used is too dark (pl. 28).

The following three are the worst ones:

1. No trace of buff-yellow has been depicted on the chin, throat and foreneck of the Great Slaty Woodpecker (pl. 10, fig. 5).
2. The Blackrumped Magpie (pl. 18, fig. 3) shows brownish patches on the sides of the head and upper back, and a lot of green on the tail.
3. The Streaked Laughing Thrush (pl. 22,

fig. 2) shows grey instead of olive brown on the rump and upper tail coverts. Moreover, the bird should have been placed on the ground for it is highly terrestrial.

The following errors in drawing have also been noticed:

1. The chestnut patch on the breast of the Redbreasted Hill Partridge (pl. 5, fig. 4) never has as clear-cut an outline as depicted.
2. The bill of the Ashy Swallow-Shrike (pl. 12, fig. 3) should be finch-like.
3. The tail of the Yellowbilled Blue Magpie (pl. 14, fig. 3) is disproportionately short.
4. There should be no white patch on the throat of the Orangeheaded Ground Thrush (pl. 31, fig. 8).

Furthermore, there are no scales on plates 14, 19, 21, 34 and 37.

In contrast to the printing of the plates, the printing of the text matter is excellent and the binding neat.

In the next edition, some important publications on birds of the area (e.g. Sikkim Himalaya by Stevens, Sikkim by Sálim Ali, Darjeeling and its neighbourhood by Mathews and Edwards, etc.) could perhaps be suggested by the author for further reading by any one interested. This will surely greatly enhance the utility of this field guide.

Nevertheless, it is a very important addition to Indian ornithology, and will prove very useful and helpful to naturalists, birdwatchers and others interested in birds of the eastern Himalayas.

Biswamoy Biswas

MISCELLANEOUS NOTES

1. OCCURRENCE AND OBSERVATIONS ON *TADARIDA AEGYPTIACA* (E. GEOFFROY, 1818) (MOLOSSIDAE : CHIROPTERA); THE WRINKLE-LIPPED BAT IN EAST-NIMAR DISTRICT, MADHYA PRADESH (INDIA)

During a recent survey of bats of East-Nimar the presence of *Tadarida aegyptiaca* (Geoffroy, 1818) belonging to the family Molossidae of bats was recorded in three different localities. Certain observations on this species are recorded.

Between December 1975 and April 1977, 142 specimens were collected. Specimens were collected with the help of mist-net or shot at frequent intervals.

Brosset (1962) in his study on bats of Central and Western India recorded some of the species of family Molossidae from six localities. This species *Tadarida aegyptiaca* of genus *Tadarida* (Molossidae: Chiroptera) has not so far been recorded from East Nimar (Khandwa, Burhanpur, Asirgarh) of Madhya Pradesh (Blanford 1891), Ellerman, J. R. and Morrison-Scott (1951). This region has very low rainfall and it remains arid throughout the year.

In this survey of bats of East-Nimar three colonies of *Tadarida aegyptiaca* were located in different locations.

Collection Localities: A brief description of the collection localities is as given below.

1. In the old building of S. N. Govt. College, Khandwa.
2. In the old fort at Burhanpur.
3. In the old fort at Asirgarh.

The three colonies were found in buildings. In each colony the number of individuals was between fifty to hundred. All colonies of *Tadarida aegyptiaca* have similar type of roosting sites. They are in the narrow and deep crevices in the stones of the large old forts and buildings. At Khandwa, colonies were located within ten yards of each other in deep crevices of 8 feet vertical elongation. Note may be taken here that these crevices are 15 to 25 feet above the ground but at Burhanpur and Asirgarh it is over 50 feet from the ground level.

The wrinkle-lipped bats are easily detected. They conceal themselves very well, but are found on account of their extremely noisy behaviour during the day. The smell of their guano and its shape make it possible to identify them in narrow crevices.

Tadarida aegyptiaca has broad, rounded, thick ears and they are joined on the front of muzzle, and about half a portion of its tail is covered by femoral membrane. The shape of its wings is narrow and it has a greater length in its horizontal plane. The feet have a row of stiff hairs. These all are a diagnostic feature of family molossidae.

There is a marked variation in the colour of its fur. This has been noticed in two individuals of same colony.

Three principal types given below are mainly observed.

(i) Light brown above and grey below.
(ii) Warm brown above and brown grey below.
(iii) Blackish grey above and grey below.

According to my observation of these colonies of *Tadarida aegyptiaca*, this bat does not fly very early at sun-set, but it depends upon the seasons. Usually they fly half an hour after sun-set. All of them emerge only from a few specific crevices of their habitat while coming out they produce a special type of sound. The observation of Brosset (1962) that after ten minutes of departure crevices were completely empty may be correct. However, I observed that during a year the colonies are completely empty only on 4 or 5 days. Generally four or five bats keep on moving inside their roosting crevices.

Quoting the statement of Verschuren, Brosset (1962) says that they do not come back to their diurnal roost for at least two hours after they had left it. It may be mentioned in this regard that some of them returned just after ten minutes of their departure in my presence and I could successfully trap a few specimens while they were trying to enter their habitat at a distance of ten feet from their colonies.

Tadarida aegyptiaca hunts far away from the roosting sites, but after ten minutes of hunting they start returning to their roosting sites. This bat usually hunts at a height of 100 to 250 feet from the ground. They can be identified from their peculiar sharp calls at the feeding ground.

It was observed in the colonies of East-Nimar that *Tadarida aegyptiaca* migrate in the month of April. They return usually in groups again in the month of June. The area to which they migrate is yet to be traced. Banded bats have not been recovered from other colony sites. It may be possible that their migratory sites are far from their original roosting colonies. It seems that this displacement or movement of *Tadarida aegyptiaca* are connected with high temperature which in East Nimar crosses 35°C in the month of May. This migratory behaviour of *Tadarida aegyptiaca* appears to be similar to that of *Tadarida brasiliensis mexicana* (Saussre) of Arizona (Cockrum 1967).

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2. OBSERVATIONS ON ECOLOGY AND BEHAVIOUR OF THE RHESUS MONKEY *MACACA MULATTA*, IN ASARORI

INTRODUCTION

The present account gives the more important results of a nine-month field study on the ecology and behaviour of rhesus macaque (*Macaca mulatta*) in the Asarori Forest, near Dehra Dun (Uttar Pradesh, Northern India), carried out during January to October 1976. The forest is of moist deciduous type, and consists mainly of large *sal* trees (*Shorea robusta*). Here a fairly good population of the rhesus as well as the Hanuman langur (*Presbytis entellus* Dufresne) coexist.

OBSERVATIONS

1. *Group size and composition*: Some 14 groups of rhesus monkeys were present comprising a total of about 500 individuals; four solitary males were also observed. Detailed studies were made on six groups, whose size varied from 5-*c*. 90 (mean 32.8) individuals. All groups, except one, were of the bisexual multimale type. The exception was an all-juvenile group of 5 individuals. The number of adult males in a group varied from 2-7 and of adult females from 4-27. The adult sex ratio was male 1: female 2.2-3.7. The mean ratio for adult female to young infants for four groups was 1:0.7; this shows high reproductivity (70%).

2. *Home range*: The home range area varied from 1.3-13.4 km^2 and was correlated with group size (correlation coefficient $r=0.937$, significant at $P=0.01$). The home ranges of neighbouring groups overlap considerably (23.5—100%, mean 61.1% of their area).

3. *Food and feeding*: The rhesus is largely vegetarian, eating various components of some 85 different plants. But some animal food is also eaten regularly, this consists mainly of insects of all kinds such as beetles (including water beetles) and their grubs, moths, butterflies and their pupae, grasshoppers, termites, cocoons of hymenoptera and spiders and their webs. Insects are caught with a quick movement and the uneatable appendages are removed with the hand before eating. During the monsoon months two species of fungi are eaten in abundance. Occasionally they eat earth from termite mounds and lick the lime washed walls of forest quarters. Strange food, such as carrots, Indian *chapaties*, when offered is rejected after inspection and testing it by a little chewing. During summer the animals drank daily or on alternate days, and in winter about once a week. Casual intake of water in winter occurred regularly by licking dew from leaves.

4. *Foraging routes*: A group was followed from dawn to dusk for 15 consecutive days to determine the actual distances travelled for foraging. The length travelled ranged from 1050-3500 m (mean 1803.3 ± 160.2) and this determines the distance between the two consecutive roosting sites. The two are closely related (correlation coefficient $r=0.63$, significant at $P=0.01$).

5. *Roosting*: Groups of tall trees serve as the night roosting sites, which are changed every night, as was noted in detail in two groups for a period of one month each. Certain areas of home range are used frequently for roosting and may be called "roosting sites." In both groups 'the area of 'roosting sites forms about 47% of the total area of the home range, irrespective of the size of the latter. The mean distance between

the two roosting sites (for two successive nights) was 431 ± 56 m in the Harbhajwala group and 1247.5 ± 110 m for the Bada group. This feature is directly related to group size (31 and *c*. 90 respectively).

6. *Dominance* : The dominant male or leader of a group can be easily identified by his robust body and certain characteristics. His tail is carried high up with a tight end loop, especially when in encounters other animals and also in inter and intra group encounters. He usually leads a group, gives threats to intruders and gives dominance displays by shaking tree branches. Almost all females and young seek his support in case of danger. He frequently dashes to site of intra group squabbles and his presence has an immediate calming effect. His aggressive activities are more frequent than those of other males of the group, and he enjoys priorities in all activites. Curiously, he also shows some paternal behaviour whose intensity varies with the individual. One leader was observed carrying, protecting, grooming and roosting with an 8-month old infant.

7. *Intergroup relations* : Groups are intolerant of the proximity of other groups and intergroup spacing or avoidance is noticeable. Although the home ranges of neighbouring groups overlap considerably, intergroup interactions are infrequent. Only 19 interactions were noted during a period of nine months. In encounters, a dominance display is common rather than fighting. The period of interactions varied from 2 to as long as 60 minutes. Usually subordinate males lead in chase during a fight.

Intergroup dominance is positively correlated (89.5% of the cases) with group size. Sometimes the dominant male of a group mounts adult female of his own group during encounters. Four types of encounters were noticed: overtly aggressive (5.3%), aggressive (36.8%), aggressive-tolerant (10.5%) and approach-withdrawal (47.4%).

8. *Interspecies dominance* : Occasionally, rhesus and langur groups interact with one another, and the latter always displays subordination by avoiding the former. Although the langurs are larger and heavier, they withdraw and are threatened and chased by the rhesus. This agrees with Roonwal's (1976) view that some other factors other than body weight and size determine interspecies dominance.

DISCUSSION

Group size and composition, as studied by various workers in different habitats show variation, but groups are mostly bisexual and multimale. Rarely, groups without adult males are also found (Neville 1968a; Makwana, in press). Southwick *et al.* (1965) give the average size of groups as 50 (for 5 forest groups), Jay and Lindburg (1965) 32 (for 14 groups), Lindburg (1971) 23 (for 5 groups near Dehra Dun), Neville (1968b), 41 (for 5 Forest groups near Haldwani), Mandal (1964) a range of 5-35 (for 29 groups in the Sunderbans), and Puget (1971) an unusual size range of 90-180 in northeastern Afganistan. Solitary males are also occasionally found.

The extent of home ranges also varies greatly. In Uttar Pradesh, Neville (1968b) recorded 1-3 km^2 in forest near Haldwani, and 0.05 km^2 in Haldwani town. Lindburg (1971), 16 km^2 near Dehra Dun and the present range is 1.3-13.4 km^2 in Asarori.

The roosting sites of urban groups are fixed and groups roost there every day (Southwick *et al.* 1965; Singh 1969). But in forest habitat roosting sites are changed daily (Lindburg 1971 and present study).

Foraging routes are apparently determined arbitrarily and their length may vary from *c.* 200-3500 m; Lindburg 1971, 350-2820 m; Neville 1968b; 200-400 m; the present study 1050-3500 m). A group always travels a longer distance than the actual straightline distance between two consecutive roosting sites. Factors which may determine the length of foraging routes are the availability of food and water, the season, the position of neighbouring groups, the group size, etc.

Inspite of much overlap in the home range area, intergroup encounters are infrequent and usually group avoidance is noticed rather than fight. This situation was also observed by Southwick *et al.* (1965) and Lindburg (1971).

ACKNOWLEDGEMENTS

I am indebted to Prof. M. L. Roonwal, Jodhpur, for his keen interest and encouragement, to Prof. S. D. Singh for working facilities; and to Dr. S. M. Mohnot for assistance with literature.

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3. A NOTE ON THE BREEDING AND LONGEVITY OF THE INDIAN PANGOLIN (*MANIS CRASSICAUDATA*) IN CAPTIVITY

A pair of adult Indian Pangolins (*Manis crassicaudata*) was acquired for the Nandankanan Biological Park, Orissa. The female arrived on 16th July 1973 and the male arrived on 16th July 1976. They were housed in an enclosure measuring 2.5 × 1.5 × 2 m. high. Attached to the enclosure is a dark sleeping den measuring 0.85 × 0.5 × 0.5 m high. They remain curled up throughout the day in the sleeping den and became active from late evening to early morning. They sometimes climb up a cement tree erected inside the enclosure. They are fed with red tree ants (adults, young and eggs) every evening at the rate of 600 gms per day per adult and occasionally some termites with combs.

A male young was born to the female of this pair on 7-4-1977 early morning but the young was found dead on 8-4-1977. The young measured 33 cm tip to tip including 12 cm long tail and weighed 242 g. The eyes were open and the scales were soft at birth. The mother Pangolin weighed 7.920 Kg and the male weighed 9.250 Kg on 10-4-1977.

The female Pangolin died on 1 December 1977 establishing a longevity of 4 years, 4 months and 16 days in captivity. The details of other five Indian Pangolins which have lived for over 1 year in the Park on a diet of red tree ants and termites are as follows.

Sl. No.	Date of arrival in the Park	Date of death in the Park	Period of survival in the Park
1	31-7-1972	3-12-1974	2 years, 4 months and 4 days.
2	3-11-1973	19-5-1976	2 years, 6 months and 17 days.
3	22-6-1976	26-12-1977	1 year, 6 months and 5 days.
4	16-7-1976	Living on the day of this report	Over 1 year and 8 months.
5	25-9-1976	Living on the day of this report	Over 1 year and 6 months.

There are records of birth of this species in India in July (Prater 1971) and November (Asdell 1964; Acharjyo and Misra 1972). The litter size is usually 1 and occasionally 2 (Asdell, loc. cit.). A new-born young measured 30 cm from tip to tip including 12.5 cm long tail and weighed 235 grams (Acharjyo and Misra, loc. cit.).

A Pangolin lived in captivity for 2 years (Prater, loc. cit.). According to Yadav (1973) Jaipur Zoo has reared Pangolins for a period of over six months. Out of three Indian Pangolins received at New York Zoological Park on 28 April 1961, one lived for 4 months, another for 7 months but the third one remained in good condition till late 1963 (Crandall 1965). Narayanan (1977) reports that one Pangolin survived for a little more than 2 years in captivity at USPHS—JIPMER Leprosy Research Project, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry.

ACKNOWLEDGEMENTS

We wish to express our sincere gratitude to Shri G. M. Dash, I.F.S., Chief Wild Life Warden, Orissa and to Shri S. Jee, I.F.S., Chief Conservator of Forests, Orissa for their help and encouragement.

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4. THE BRONZEWINGED JACANA *METOPIDIUS INDICUS* (LATHAM) IN SAURASHTRA AT JAMNAGAR

In a communication from Jamnagar, Saurashtra, Shri Lalsinhbhai Raol writes to report the first ever record of a Bronzewinged Jacana in the Saurashtra peninsula. He writes:

'There is a fairly big reservoir in Jamnagar City. Egrets, herons, storks, ibises, stilts, Red-wattled and Yellow-wattled Lapwings and wintering ducks and waders can be seen here.

On 6th March 1977 I noticed an unusual bird on a small islet in the lake. Examining it through field glasses I was thrilled to find a bird familiar from looking at the illustration in my "Sálim Ali", but an addition to my life-list.

If my memory of our notes compared does not fail me, this species is uncommon in mainland Gujarat, but has never been recorded from Saurashtra. Dharmakumarsinhji lists it in the supplement for Birds of Gujarat in his book BIRDS OF SAURASHTRA, and does not include it in his Saurashtra bird descriptions.'

Sálim Ali & S. Dillon Ripley in the HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN, Vol. 2, say that the species is absent from western Punjab and western Rajasthan. However, there are records of this bird from Kutch (Humayun Abdulali, *JBNHS 40*: 122) seen at the Hemissar Tank in June 1937. Dr. Sálim Ali in THE BIRDS OF KUTCH (1945) describes its status in Kutch as "Resident (or local migrant?). Uncommon", and in 'The birds of Gujarat' (*JBNHS* 52: 413) states that though no specimens have been collected it has been noted at Bhuj (Kutch) also by Humayun Abdulali in June (ibid. 40: 122) and several places in Gujarat in vegetation-covered tanks and jheels, but that it is decidedly uncommon.

C/o. WORLD WILDLIFE FUND-INDIA,
SHAHID BHAGAT SINGH ROAD,
BOMBAY-400 023,
August 25, 1977.

LAVKUMAR KHACHER

5. ON THE OCCURRENCE OF THE BLACK-NAPED GREEN WOODPECKER, *PICUS CANUS HESSEI* GYLDENSTOLPE (PICIFORMES : PICIDAE) IN ORISSA

During the course of a faunistic survey in Orissa in 1976, I collected a female specimen of *Picus canus hessei* Gyldenstolpe on 12 March, from Dhuanali, Puri district. Its measurements (in mm.) are: Wing 148, bill from skull 36, tail 100, tarsus 12, and its weight is 137 g.

The Assam population of the Blacknaped Green Woodpecker was separated from *Picus canus hessei* Gyldenstolpe, 1916, as *Picus canus gyldenstolpei* by Baker (1918) on the basis of slight differences in coloration and size. Vaurie (1959), however, treated *gyldenstolpei* as a synonym of *hessei*, since there is very little difference warranting their separation. Ali & Ripley (1970, p. 189, note) while admitting *gyldenstolpei* stated that *hessei* 'is doubtfully separable from' it. On a re-examination of the material available in this department, however, I am inclined to agree with Vaurie (op. cit.) in not recognizing *gyldenstolpei* as a distinct subspecies.

According to Vaurie (1965) this subspecies occurs in Indochinese countries (with the exception of northeastern Tonkin, northeastern Burma and peninsular Thailand), Assam south to the Lushai Hills (= Mizoram), and eastern Himalaya to Sikkim. As far as known from the extant literature on Indian avifauna *e.g.*, Baker (1927), Ali & Ripley (1970), etc., this species has not so far been reported from Orissa.

The present example reported for the first time from peninsular India extends its distribution as far south as Orissa.

ZOOLOGICAL SURVEY OF INDIA,
INDIAN MUSEUM,
CALCUTTA-700 016,
June 24, 1977.

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6. SIGHTING OF THE INDIAN PITTA (*PITTA BRACHYURA*) IN PAKISTAN

The Indian Pitta spreads across the Himalayan foothill zone during the monsoon season when it breeds but it does not appear to have been recorded further west than Dharamsala (Whistler HANDBOOK 1949), or Simla (Ripley, S. D., SYNOPSIS 1961). There are no records of its occurrence in Pakistan territory even in the Murree Hill region where several species were recorded at the turn of the century which no longer appear to survive or visit this area at the present time.

On June 17th 1978 I was visiting a jungle clad region at the foot of the Margalla Hills just west of Islamabad city when I heard a strange bird calling. Upon investigation this turned out to be the Indian Pitta. There was a pair frequenting the steep hillside above a stream and I had clear views of what was presumably the male singing from the top of a stunted wild fig tree. The location was at about 2,000 feet elevation and hardly more than three miles from the outskirts of Islamabad (33°28′N, 73°03′E). The World Wildlife Fund Appeal had chosen this site for construction of a pre-release pen for the Cheer Pheasant (*Catreus wallichii*) which has been bred in captivity and is now believed to be extinct in the Margalla Hills. Dr. Sheldon Severinghaus was visiting Pakistan to assist with this project and I was able to bring him the next morning to observe these Pittas. He made recordings of the male which are now lodged in the Cornell University library of bird sounds. I was able to visit the area again on July 13th 1978 at which time one individual was still in the same vicinity and heard calling, however when I reported this find to a keen ornithologist friend, Mr. T. J. Roberts he failed to find any trace of these birds on July 28th. The Margalla Hills are covered with dry tropical deciduous type of scrub forest and would seem to provide ideal habitat for Pittas.

C-24, K. D. A. Scheme No. 1,
Drigh Road, Karachi,
Pakistan,
August 7, 1978.

KAMAL ISLAM

7. A NEW BIRD FOR NEPAL AND NOTES ON OTHER SCARCE SPECIES

At 16.00 hours on 23rd February 1978 I was fortunate enough to be drifting downstream along the main channel of the Narayani River just below its confluence with the River Rapti in the Nepalese terai when I spotted a swan some 200 yards ahead. My companions were principally amateur European bird-watchers and naturalists, members of a special interest tour I was leading for Town and Gown Travel of Oxford, UK, as well as Khadak Kumar of Tiger Tops Jungle Lodge staff. As we drifted closer the pure white plumage, smallish size and yellow area at the base of the black bill became visible. I turned the boats and we approached within about 80 yards to obtain excellent views of the truncated (not pointed) yellow area at the base of the bill. At this point the bird pattered over the surface showing its black feet, and took to the air with neither wing sound nor call. In the air the comparatively rapid wing beats and general compactness reinforced my identification of this bird as a fully adult, wild Bewick's Swan *Cygnus columbianus*. Sálim Ali and S. Dillon Ripley's HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN list five records for the sub-continent, none in Nepal. R. L. Fleming Sr., R. L. Fleming Jr., and L. S.

Bangdel do not include the species in their BIRDS OF NEPAL. By good fortune I was able to talk to R. L. Fleming Jr., within a couple of days and he confirmed that there were no previous records for Nepal. It should be added that as a European resident I have observed thousands of these birds over the years and would not consider them difficult to identify.

The weather at this time was quite severe in the hills and R. L. Fleming Jr., considered it an exceptionally hard winter. Certainly it had produced several records of unusual northern passerine species in and around the Kathmandu valley.

On 26th February 1978 I was once again drifting downstream on the Narayani River, this time in company with Peter Jackson of the World Wildlife Fund, Morges; David Smith of the Smithsonian Tiger Ecology Project; Charles McDougal, Director of Wildlife at Tiger Tops Jungle Lodge; and Michael Price of Survival Anglia. Our aim was to explore the new western extension of Chitawan National Park. Within an hour of leaving the Narayani-Rapti confluence we encountered several large flocks of duck. Mostly these were Brahminy Duck *Tadorna ferruginea,* Teal *Anas crecca,* Wigeon *A. penelope,* Pintail *A. acuta* with some Goosander *Mergus merganser,* Gadwall *Anas strepera* and Red-crested Pochard *Netta rufina.* Then I spotted a drake Goldeneye *Bucephala clangula* followed soon afterwards by a drake Falcated Teal *Anas falcata.* The Goldeneye is the third record for Nepal, the Falcated Teal the first record for Nepal away from the Kosi River. Both birds were also seen by Peter Jackson and Michael Price, two experienced observers.

On 28th February 1978 the same party was finishing its trek beside the Narayani at Mohan Khola about five miles downstream from the Narayani-Rapti confluence. A large raptor appeared and gave excellent views as it circled overhead. Its general coloration was dark brown with a faint light line along the edges of the under-wing coverts. The head was prominent and the wings long and broad and held well forward. Clearly an eagle, its identification was ensured by the prominent and distinctly wedge-shaped tail. The bird was immature and lacked the white retrices of the adult White-tailed Sea Eagle *Haliaeetus albicilla.* However, by good fortune, I had seen a transparency of an individual in similar plumage only two weeks or so before. The tail feathers formed a distinctive wedge and against the light each retrice was edged all round with a darker colour giving the effect of a "leaded window" of the tail feathers and indicating a second or third year bird. This bird constitutes the second record for Nepal, the first being an adult at Pokhara in 1971.

JOHN GOODERS

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March 25, 1978.

8. ON THE PHENOMENON OF NOCTURNAL FLIGHTS OF SOME RESIDENT BIRDS AT LUNGLEI, MIZORAM, N. E. INDIA

During a faunistic survey of Mizoram in 1976, our attention was drawn to a report of frequent casualities of birds occurring annually, by dashing to death against walls of a building at Lunglei, Lunglei district, Mizoram. We visited the building in November, 1976 with a view to study the phenomenon, but were told that the birds fly in only during the months of September and October. However, the owner of the building, Dr. Doliana, a retired Civil Surgeon at his Aizwal residence furnished valuable information in addition to presenting some specimens of parts of birds which he had preserved out of those killed during the accidents. We also obtained some of the feathers of the dead birds for identification from the building where the feathers are kept as wall-decoration.

The building stands at a height of 1210 m amidst rugged mountain ridges. It has three prominent electric lights fitted on the same plane in front of the building. As the bulbs are of high intensity, of more than 100 watt power, they are easily seen at night even from far off distances. The birds are attracted by the lights and dash themselves headlong against the roof and walls of the building and thus get killed. The following additional information has been obtained from Dr. Doliana:

1. The birds have been observed to dash against the building in late September and early October during which period the area receives late monsoon rains.
2. The phenomenon occurs when the sky remains over-cast with clouds, i.e. without moonlight and with fog and mist. A little drizzle appears favourable.
3. The birds usually fly from west to east during 7 p.m. to 10 p.m.

The above three points are extremely similar to those reported by Sálim Ali (1962) for Haflong except that at Haflong the birds came from the north. The number of birds which get killed annually reportedly vary from 300 to 500. Dr. Doliana has made record of such deaths since 1974, and the apparent number of species vary from 6 to 8.

The following identification is based on parts of specimens obtained from Dr. Doliana and from the building.

1. Indian Moorhen: *Gallinula chloropus indica* Blyth.
2. Greyfronted Green pigeon: *Treron pompadora.*
3. Indian Emerald Dove: *Chalcophaps indica.* Sálim Ali (1962) mentions frequent casualties of this bird and the green pigeon in the coffee plantations of Mysore and Kerala.
4. Indian Threetoed Forest Kingfisher: *Ceyx erithacus.*
5. Indian Ruddy kingfisher: *Halcyon coromanda coromanda* (Latham). There are several records of this species getting killed under similar circumstances in other places. Robinson & Chasen (1927) observed nocturnal fall of this bird at light houses and light strips in the straits of Malacca in autumn. Sálim Ali (1962) mentions this species being regularly picked at lights on certain mountain ridges of Jatinga (Hafflong) in North Cachar Hills in Assam in dark monsoon nights.
6. Hooded Pitta: *Pitta sordida cucullata* Hartlaub.
7. Drongo Cuckoo: *Surniculus lugubris*
8. Cuckoo: *Cuculus canorus*

It is clear from the above list that all the birds killed are of *resident species.* Sálim Ali (1962) and Gee (1964) have recorded similar phenomenon in Jatinga near Haflong, where petromax lamps are used by the villagers to attract birds. In both the places two common observations are made: that (i) almost all the species are resident birds; and (ii) green pigeons (*Treron* sp.) in considerable numbers are reported to be attracted by light. Although some of these birds namely, Emerald Dove, Greyfronted Green pigeon, Three-toed Forest kingfisher and Indian Ruddy kingfisher are known to dash against obstacles and die, it is not still clearly understood why these 'non migratory' birds fly into the lights and that too in one particular time of the year and in a particular place or two alone.

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We thank Dr. H. Khajuria, Deputy Director, E.R.S., Shillong for permitting the authors to undertake the survey and for going through the manuscript and Dr. A. K. Ghosh, Zoologist, for valuable suggestions offered. The Bombay Natural History Society kindly identified the bird parts.

K. R. RAO
R. ZORAMTHANGA

ZOOLOGICAL SURVEY OF INDIA,
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SHILLONG-3,
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*ROBINSON, H. C. & CHASEN, F. N. (1927): The birds of Malay Peninsula *1*: 102. H.F. & C.G. Witherby, London.

* Not seen by the authors.

9. NOTES ON DISTRIBUTION, SEXUAL DIMORPHISM AND GROWTH IN CAPTIVITY OF *GEOCHELONE ELONGATA* (BLYTH)

(*With a text-figure*)

Distribution: This species is so far known to occur in India from Jalpaiguri district, E. Bengal and Singbhum district, Bihar (Chaibassa and Chotanagpur) as recorded in the collection of Zoological Survey of India excluding the female specimen from Orissa mentioned below. Outside India the species occurs in Nepal, Bangladesh (Akyab and Chittagong Hill tracts), Burma, Thailand. According to Smith (1931)[1] Nepal is the north eastern limit of the range of the species in the Indian subcontinent. This is an example of an Indochinese species in Peninsular India. This common land tortoise of eastern India is becoming rare with the restriction of Sal forest.

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[1] Smith, M. A. (1931): The Fauna of British India. Vol. I.

Habits and habitats: Two specimens were collected from the forest floor of hill "Sal" forests while moving among the dry Sal leaves. Their preference for fallen flower petals within the enclosure suggests that they possibly feed on fallen Sal flowers in nature. Their distribution also is closely associated with the Sal (*Shorea robusta*) and Teak (*Tectona grandis*) forests of the Indian and Indochinese subregion. In winter they are less active than in the summer or rainy season.

Sexual dimorphism: The distinguishing characters of this species are prominent. The body of the male is comparatively narrower and deeper than the females. The nuchal shield as well as the angle of bifurcation of anal shields (plastron) (Text-fig. 1) in male are much narrower and also the tail is longer and more curved than in the female. In rare cases the nuchal may be absent. Smith (loc. cit.) found the nuchal wanting in one out of 60 specimens and Anderson in 4 specimens. There is no colour difference. The shell is greenish-yellow or yellow and each shield has a irregular black blotch. In our specimen's shell this blotch is wanting.

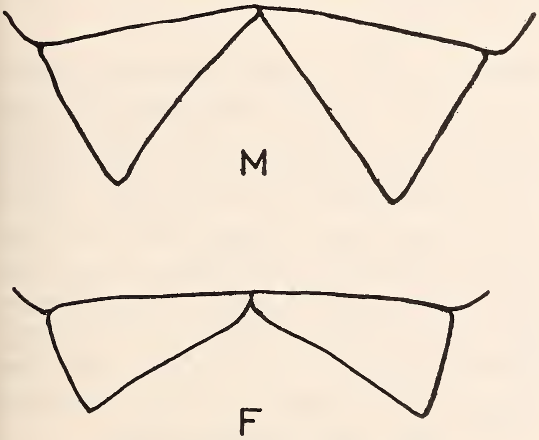

Fig. 1. *Geochelone elongata* Blyth.
Life size figure showing the anal bifurcation in male (M) and female (F).

Growth: Measurements and weight were taken of the male and female on 27-1-74 and after a gap of two years the male was measured and weighed on 27-1-77 and 23-1-78. From the size and weight it is presumed that both were of the same age group but the male is slightly larger. The annual weight gain by the male was more in the 4th year (245 gm) than in its 2nd year (150 gm). The following measurements indicate that the growth of the species is very slow in captivity:

Food: The two tortoises were fed everyday on cut pieces of Banana, "Sag" or vegetables, soaked Bengal gram, "Doob" grass (*Cynodon dactylon*). They took all these food and also petals of flowers fallen inside the enclosure.

Breeding season: The breeding season appears to start in the month of July because the male was observed to try and mate twice on 7.7.77 and 9.7.77 with a female *G. elegans*.

The female reported herein was collected

Sex	♀	♂	♂		
Dt. of measurement	27-1-74	27-1-74	25-1-75	23-1-76	23-1-78
Length of carapace in mm.	220	238	—	242	244
Breadth of carapace	154	148	—	166	168
Length of Plastron	190	192	—	195	197
Weight in Kg.	1.675	1.770	1.920	2.105	2.350
Depth of body	103	112			

on 27th April 1969 from a forest in Puri district and the male on 22nd February 1971 from the forests of Simuli Pahar, Mayurbhanj district by the D.F.O., Puri Division and A.C.F., National Park, Joshipur respectively and were sent to the Nandankanan Biological Park. Unfortunately the female died on 26.5.74. The male is now being kept with 4 specimens of star tortoise *G. elegans* (Schoepff).

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July 25, 1978.

10. HEARING ABILITY OF BROWNTREE SNAKE (*DENDRELAPHIS TRISTIS*)

While studying the feeding behaviour of Barbets (*Megalaima*) on 2.xi.77 at Borivli National Park, I noticed an interesting phenomenon. I was sitting in my bush hide under a big *Ficus mysorensis* and observing Barbets feeding on Ficus receptacles. At 10.05 hrs. when I looked at the ground I saw a Browntree snake lying on an arched log at a distance of about 2½ m from me. The snake was about a metre in length and its anterior portion was erected up at an angle of 45°. In the meantime when we (the snake and I) were looking at each other an aeroplane's sound was heard. As soon as the sound was heard the snake lifted up its head, as if trying to see the source of the sound, making an angle of 90° and remained in this position till the sound faded; then it resumed its former position. We were both situated under the thick foliage of the Ficus tree and there was no question of sighting the plane or its shadow passing over our head. Nothing except the sound of the plane was the cause for the snake to change its position. I think it has good hearing capacity.

SHAEQUE AHMAD YAHYA

Research Scholar,
Bombay Natural History Society,
Hornbill House, S. B. Singh Road,
Bombay 400 023,
June 13, 1978.

[Dr. Carl Gans whose opinion was requested comments:

Snakes can hear quite well to 1500 Hz, and the sound of the plane would have components in that range. Consequently, there is a possibility that the snake responded to the sound. It would be surprising if the snake did indeed present an obvious behavioural response. On the other hand, such one-time observations hardly constitute a very high level of proof, rather they are incidental observations that must be checked out by experiment. As it is, the snake might have responded to movements of the wind or to chemical cues, which the author could not have observed.—EDS.]

11. RECORD OF *PTEROMALUS PUPARUM* LINN. (PTEROMALIDAE : HYMENOPTERA) FROM THE PUPA OF LEMON BUTTERFLY, *PAPILIO DEMOLEUS* LINN. AT LUDHIANA, PUNJAB (INDIA)

During the last week of May 1976, a dry pupa of lemon butterfly was collected from a citrus tree and when opened, as many as 124 cream coloured pupae of the parasite were recovered. The adults that emerged were identified as *Pteromalus puparum* Linn. (Pteromalidae: Hymenoptera).

The species is recorded as an important pupal parasite of *Pieris brassicae* Linn., *Pieris rapae* Linn. and *Pieris deplidice* Linn. (Du Porte 1914, Zacharov 1915, Zorin 1937). However, it has also been recorded on yellow-edge butterfly *Euvanessa antiopa* Linn. (Johannsen 1913), frit fly *Oscinella frit* Linn. (Collin 1918), *Apanteles glomaratus* Linn. (Gautier 1919), *Aporia crataegi* Linn. (Martelli 1931), Hemlock looper *Ellopia fiscellaria* Gn. (Schedl 1931), *Vanessa urticae* Linn. (Zorin 1937), Sawfly *Diprion pini* Linn. (Otten 1943), *Melacosoma neustria* Linn. (Romanova 1951) and *Papilio demodocus* Esp. (Abu Yaman 1973). This is apparently the first record of *Pteromalus puparum* Linn. parasitising pupa of *Papilio demoleus* Linn.

ACKNOWLEDGEMENTS

We are thankful to Dr. A. S. Sidhu, Professor and Head, Department of Entomology, Punjab Agricultural University, Ludhiana for providing the necessary facilities and to the Director, British Museum, Commonwealth Institute of Entomology, London for identification of the parasite.

DEPARTMENT OF ENTOMOLOGY,
PUNJAB AGRICULTURAL UNIVERSITY,
LUDHIANA,
December 22, 1977.

M. RAMZAN
DARSHAN SINGH

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12. NEW RECORD OF *DIMEROMICRUS VIBIDIA* (WALKER) (HYMENOPTERA : TORYMIDAE), A PARASITE OF THE GALL FLY *PROCECIDOCHARES UTILIS* (STONE) (DIPTERA : TEPHRITIDAE) FROM NEPAL

The gall fly *Procecidochares utilis* (Stone) is a serious pest of the crofton weed *Eupatorium adenophorum* Sprengel and is employed for the control of this weed in many parts of the world.

A hymenopterous parasite *Dimeromicrus vibidia* (Walker) (Torymidae) was reared from the larvae of this fruit fly in Kathmandu and this is the first record of the insect parasitising *P. utilis*. The only other insect known to parasitise the insect in Hawaii is *Opius tryoni* (Cam.) (Dodd 1953).

From 20 galls examined eight contained 16 larvae and 11 contained 21 pupae of the fruit fly, whereas six galls showed parasitisation by *D. vibidia*. Four larvae and seven pupae of the parasite were recovered. The parasitisation of the galls was noticed to be 30 per cent.

ACKNOWLEDGEMENTS

We are grateful to Mr. D. R. Uprety, Dean, Institute of Science, Tribhuvan University, Kirtipur for the facilities provided. We are also indebted to Dr. N. C. Pant, Director, Commonwealth Institute of Entomology, London for getting the parasite identified by Dr. Z. Boucek.

Zoology Instruction Committee,
Tribhuvan University, Kirtipur,
Nepal,
September 8, 1978.

V. C. KAPOOR
Y. K. MALLA

REFERENCE

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13. *UROCTEA INDICA* POCOCK (FAMILY : UROCTEIDAE) AS A NEW RECORD FROM RAJASTHAN, INDIA

(*With five text-figures*)

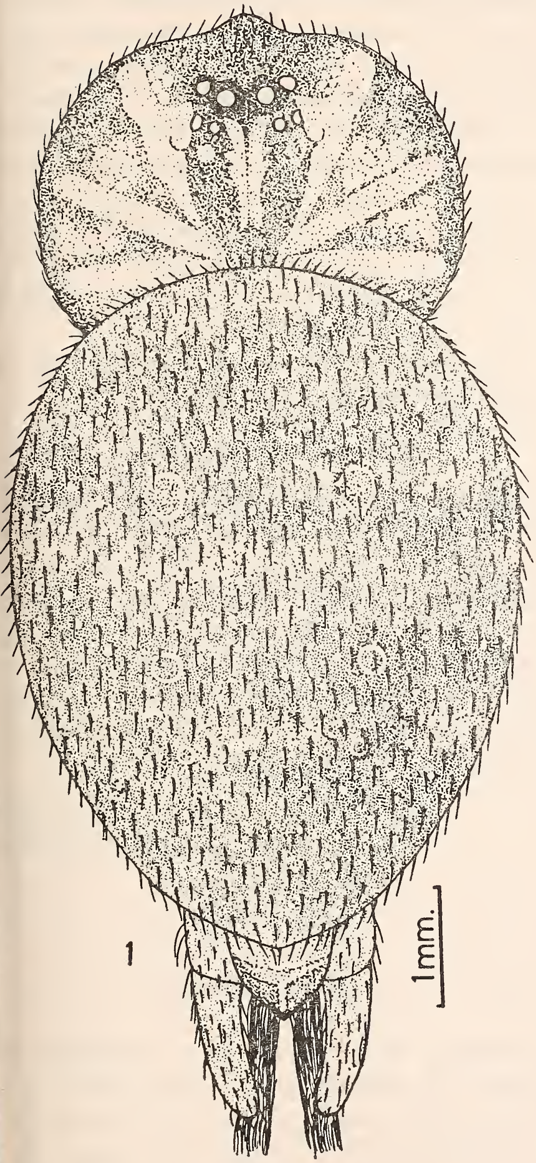

Fig. 1. *Uroctea indica* Pocock. Dorsal view of female, legs omitted.

While studying a collection of spiders from Rajasthan, we came across two females of *Uroctea indica* which was described by Pocock (1900)[1] from Poona, Maharashtra. This is the only recorded species from India. The original description is very inadequate and without illustrations. In the present paper *U. indica* Pocock is redescribed and illustrated.

Uroctea indica Pocock
(Figs. 1-5)

1900. *Uroctea indica* Pocock, Fauna Brit. India, p. 243.

Specimens exemined: 2 ♀ ♀, India, Rajasthan, Indana, Dist. Nagaur, date, 4.ix.1960. *Coll. B. Biswas* (Regd. No. 4317/18).

General: Cephalothorax and legs reddish-brown, abdomen brownish-black. Total length 8.5 mm. Carapace 2.80 mm. long, 3.70 mm. wide; abdomen 6.30 mm. long, 4.30 mm. wide.

Cephalothorax: Transversely reniform, strongly rebordered, clothed with hair. Radiating black stripes diverge from foveal region to lateral sides of cephalothorax. Eyes compact, pearly white, arranged in two distinct rows. Anterior row of eyes slightly procurved (as seen from in front); medians larger than the laterals and closer to laterals than to each other. Posterior row of eyes slightly procurved, medians slightly smaller than the laterals, widely separated from each other, closer to the adjacent laterals. Median ocular quadrangle wider than long and wider behind than in front. Chelicerae weak, vertical, dorsally clothed with hair, inner and outer margin without

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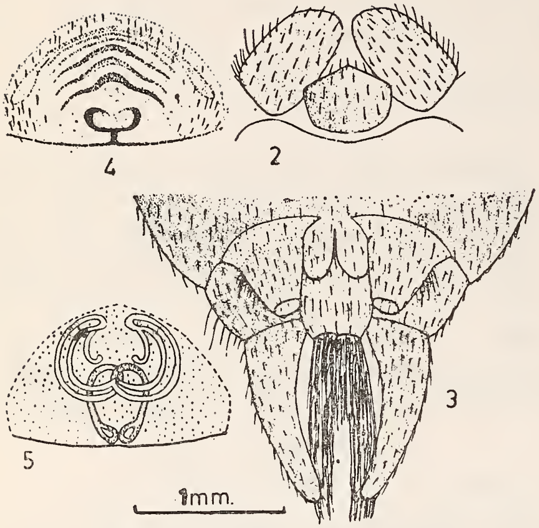
[1] Pocock, R. I. (1900): Fauna Brit. India, Arachnida. p. 243.



Figs. 2-5. *Uroctea indica* Pocock.
2. Labium and maxillae; 3. Spinnerets, ventral view;
4. Epigyne; 5. Internal genitalia.

tooth. Labium wider than long, pentagonal in shape, maxillae convergent, clothed with hair and some spine like hair, shape as in fig. 2. Sternum heart-shaped, pointed behind, clothed with long hair. Legs long, stout, clothed with hair and spines. Femur of all legs dorsally provided with black and pale patches.

Abdomen: Longer than wide, oval, clothed with spine like hair, dorsally provided with three pairs of sigilla and some round white spots as in fig. 1. Ventral side slightly lighter than the dorsal, clothed with hair and provided with four longitudinal white bands starting from epigastric furrow to the anal tubercle. Epigyne consisting of transversely elliptical plate and marked with nearly semicircular grooves in front as in fig. 4. Internal genitalia with oval spermathecae and three spermathecal ducts as in fig. 5. Spinnerets six, clothed with hair, posterior spinnerets longer than others, bisegmented, anterior spinnerets short, cylindrical as in fig. 3. The anal tubercle large, thick, bisegmented and clothed with long hair. The apical segment provided with a lateral fringe of long flexible hair.

Distribution : INDIA : Poona, Maharashtra, Rajasthan, Indana, Dist. Nagaur.

ACKNOWLEDGEMENTS

We are thankful to Dr. T. N. Ananthakrishnan, Director for providing necessary facilities and to Dr. S. K. Bhattacharya, Superintending Zoologist, Arachnology Division, for going through the manuscript and offering valuable suggestions. Thanks are also due to Dr. B. K. Tikader, Deputy Director, Zoological Survey of India, Western Regional Station, Poona, for encouragement.

U. A. GAJBE
S. BHADRA

ZOOLOGICAL SURVEY OF INDIA,
14, MADAN STREET,
CALCUTTA-13,
April 25, 1978.

14. RECORDS OF PLANTS GROWING AT HIGH ALTITUDES

It will be interesting for students of botany to know the highest altitude in the world from where flowering plants have been collected.

Sahni & Raizada (1955) during an expedition to Pancha Chuli in 1951 collected *Sedum crenulatum* Hk. f. & Th. from an altitude of 20,000 ft. Albert Zimmermann (1953), a botanist, who participated in the Everest Expedition in 1952 had collected *Arenaria, Androsace* (perhaps *Androsace microphylla*) and

Sedum sp. from an altitude of 20,850 ft. In an earlier expedition to Kamat, F. Smythe found one plant at over 21000 ft. He threw it down to R. H. Holdsworth who was at the other end of his rope, but he failed to make the catch, and in the words of Holdsworth, "the adventurous crucifer, as its probably was, lost to science".

Later, Jayal (1956-57) in his 1955 Kamet Expedition reported two flowering plants collected by his party from an altitude of 21,000 ft. without giving their names. These plants are *Ermania himalayensis* (Camb.) O. E. Schultz (*Christolea himalayensis* Camb.; *Cheiranthus himalayensis* Camb.) (Cruciferae) and *Ranunculus lobatus* Jacq. ex Camb. (Ranunculaceae) now housed at the herbarium of the Forest Research Institute, Dehra Dun (Accession Nos. 118521 and 118522).

A perusal of the available records shows these to be the highest growing flowering plants collected from the Himalayas so far. Since this information is not readily available, we are bringing it to the notice of the readers.

CCRIMH UNIT,
NATIONAL BOTANIC GARDENS,
LUCKNOW,
May 8, 1977.

N. C. SHAH
D. P. BADOLA

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15. ADDITIONS TO POACEAE OF KARNATAKA STATE

Except for Fischer's account (1937) in the Flora of Presidency of Madras there is practically no detailed enumeration on the Poaceae of Karnataka. Recently Razi (1973) has enumerated 95 species from Bangalore district and Saldanha & Nicolson (1976) 135 species from Hassan district. Based on recent botanical explorations of selected districts of Karnataka by the workers in Botanical Survey of India, a few interesting new records of grasses have been sent for publication.

In the course of further studies, we have come across many species which are either new records or interesting from the distributional point of view. A critical study of the herbarium specimens as well as a perusal of literature including the recently published floras reveals that the following species have not been recorded from Karnataka. *Arundinella intricata* has been recorded for the first time from Peninsular India. Species like *Aristida stocksii*, *Arundinella spicata*, *Arthraxon purandharensis* and *Ischaemum tumidum* which were regarded as restricted to Maharashtra State only, are now known to extend to Karnataka as well. Similarly *Garnotia courtallensis* earlier recorded from only Kerala and Tamil Nadu has been reported from Chikmagalur district (Karnataka). In the present paper aspects of distribution are discussed briefly.

All the specimens have been deposited in the regional herbarium of the Botanical Survey of India (*BSI*).

Agrostis pilosula Trin.

Fischer reports it from Nilgiris and Pulney hills only and this has now been collected from Bababudan hills at a similar high altitude of 1200 m extending the area of distribution.

Chikmagalur district: Bababudan, *Raghavan* 132431.

Aristida stocksii (Hook. f.) Domin

According to Bor (1960) the species is confined to the Concan and that "there is only a single gathering of the grass". However, this species, though infrequent, has been subsequently collected from Pune and Aurangabad districts of Maharashtra. There is a single misidentified sheet from Belgaum collected by Woodrow, which on scrutiny is referable to this species and hence it is a new report for Karnataka.

Belgaum district: Belgaum, *Woodrow* 816.

Arthraxon purandharensis Bharucha

The type locality is from Purandhar and though Jain (1972) states that it has not been collected since the original collection, this species is quite frequent at Khandala ghats (Maharashtra) and has been recorded from Mt. Abu (Rajasthan) as well. This distinct species is normally misidentified or confused with *A. meeboldii* Stapf which it very closely resembles, hence the rarity. This has now been recorded from Chikmagalur and Coorg districts of Karnataka State thereby extending its distribution further south along the Western ghats.

Coorg district: Talacauvery, *A. S. Rao* 95138.

Chikmagalur district: Kemmangundi, *Raghavan* 132386, 132397, 132529; Abbe falls, *Raghavan* 132581, 132097; Balur, *Raghavan* 126132.

Shimoga district: Jog falls, *Raghavan* 134482.

Arundinella intricata Hughes

This species has been so far recorded only from eastern India. The present report from Chikmagalur district is thus a new record for peninsular India and reveals discontinuous distribution.

Chikmagalur district: Abbe falls, *Raghavan* 134011.

A. spicata Dalz.

This pretty annual has so far been regarded as endemic to Maharashtra only, but the recent collections extend its distribution further south along the Western Ghats.

Chikmagalur district : Balur, *Raghavan* 126111; Kemmangundi, *Raghavan* 125505; Kotegehar, *Raghavan* 126212A.

Cymbopogon polyneuros (Steud.) Stapf

This grass is confined to the Nilgiris in peninsular India and has now been recorded from Chikmagalur district as well.

Chikmagalur district: Balur reserve forest, *Khisti* 120686.

Echinochloa pyramidalis (Lamk.) Hitchc. et Chase

A native of tropical Africa, this has been recently introduced in India but without any precise locality. The present report from Coorg in the wild state is hence interesting.

Coorg district: Kanbite water tank, Suntikoppa, *A. S. Rao* 86695.

Eulalia fimbriata (Hack.) O. Ktze.

According to Bor (1960), the distribution extends to "South India" but there is no record of its collection either by Fischer or in any recently published flora. Cooke (1908) reports it for Maharashtra and the present collections thus extend it to Karnataka also.

Chikmagalur district: Bharatibyle, *Khisti* 120850, Kudremukh, *Raghavan* 134289.

Garnotia courtallensis (Arn. et Nees) Thw.

It has been so far recorded from Kerala and Tamil Nadu at altitudes of 1800-2000 m and this has been collected from Bababudan ranges from similar elevations.

Chikmagalur district: Bababudan, *Raghavan* 125894; Dhupagagiri, *Raghavan* 125650; Bhagavati, *Raghavan* 126369.

Isachne globosa (Thunb.) O. Ktze. var. **effusa** (Trin. ex Hook. f.) Senaratna.

Singh & Deshpande (1973) had reported this variety from Goa as a new record for India. However, though infrequent, this species also occurs in Karnataka, extending its distribution along Western Ghats.

North Kanara district: Belvatgi, *Arora* 43705. *Coorg district*: Kalhalla, *Arora* 42084.

Ischaemum tumidum Stapf ex Bor

As to the distribution of this remarkable grass Bor (1951) mentions "Concan" (Madras State) and Khandala (Maharashtra). A critical study of the herbarium specimen records that this species has so far been collected only from Maharashtra. Fischer has also not included it for Madras Presidency, but the present collections indicate its occurrence in Karnataka as well.

North Kanara district: Sirsi, *Jain* 29889. *Shimoga district*: Hosuru, *Raghavan* 68050. *Coorg district*: Makut, *A. S. Rao* 95319.

Microstegium ciliatum (Trin.) A. Camus

This species is quite common along the Nilgiris and Palni hills and the present collection from Chikmagalur at an elevation of 1400 m confirms its occurrence on hill tops.

Chickmagalur district: Mulainagiri, *Raghavan* 134113.

ACKNOWLEDGEMENT

We are thankful to the Director, Botanical Survey of India, Howrah for facilities offered in carrying out the above work.

BOTANICAL SURVEY OF INDIA,
WESTERN CIRCLE,
7 KOREGAON ROAD,
POONA 411 001;
June 18, 1977.

R. S. RAGHAVAN
N. P. SINGH
U. R. DESHPANDE
B. G. KULKARNI

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16. THE GENUS *OPHIOGLOSSUM* IN RAJASTHAN

Ophioglossum was last surveyed in Rajasthan by Mital in 1968 when he recorded four species of the genus from Mt. Abu (*O. reticulatum, O. gramineum, O. nudicaule* and *O. costatum*) and one from Ajmer (*O. petiolatum*). A recent survey indicates that the genus is widely distributed in Rajasthan. The specific identification in this genus is based on stem character, shape of the leaf and aereoles in the leaf, we now record the following new localities for this genus in this State. All these localities are in the humid regions of the State and the genus is completely absent from the semi-arid zones. A brief description of all the localities where this genus has so far been found follows:

MT. ABU—is the richest locality for this genus since all the five species known from Rajasthan have now been recorded by us. Thus Toad rock area contains *O. reticulatum* and *O. nudicaule*. On way to Dilwara temple *O. petiolatum* and *O. gramineum* were recorded. On Trevor Toll road bifurcation we found *O. petiolatum* and *O. gramineum*. M.I.G. area on way to Gomukh contains *O. costatum* (pure stands), *O. petiolatum* and *O. gramineum* (mixed with grasses) and *O. reticulatum* (pure stand). Similarly *O. petiolatum* was recorded near Kodra dam. This species was also collected from Adhar Devi and on way to sun-set point. According to Mital (1968) this species is not found at Mt. Abu. Instead he records *O. reticulatum* from Adhar Devi which we could not find. The wide distribution of the genus at Mt. Abu is interesting by way of dynamics of species differentiation, a fact not emphasized by any of the earlier workers. Thus while pure stands of all these species were observed, certain spots showed contiguity of more than one species and in certain cases two distinct species were found in close proximity as recorded earlier by Balakrishnan *et al.* (1960) in Madhya Pradesh and Tamil Nadu. Thus on a sloppy grassland on way to Dilwara temple and in M.I.G. area *O. petiolatum* and *O. gramineum* were interminglled. A certain sequence could also be made out in our field observations regarding the occurrence of these species. Thus *O. petiolatum* appears first around July and continues till November or even later. *O. gramineum* appears much later (October) and is on the verge of disappearing by the end of November. *O. costatum* seems to be most sensitive to moisture and dries up faster than the other species.

KUMBHALGARH HILLS—This locality which is an extension of Mt. Abu hills on the north eastern side contains only *O. petiolatum* which occurs with a low frequency. However, this locality is a new record for this genus.

AJMER—This locality contains only *O. petiolatum* distributed in Nag Pahar and Antade hillocks around Ajmer as mentioned by Mital (1968). We found that the number of leaves produced per season corresponds to the period of precipitation. In the year 1975 and 1976 when excessive rainfall was recorded at this locality plants with six leaves were frequently observed by us.

MAINAL—situated about 60 km south west of Bundi, is again a new locality for this genus. Here again four species of the genus (*O. costatum, O. petiolatum, O. nudicaule* and *O. gramineum*) were recorded. It forms thus the second richest area for the genus. Again, like Mt. Abu, stands containing intermingled populations of *O. costatum* and *O. gramineum* were also observed.

BUNDI—The genus has been recorded for

the first time from three spots around Bundi. At Bhimlat (about 10 km from Bundi) *O. costatum* and *O. petiolatum* were found. However the two species were found growing in separate stands. A few plants of *O. petiolatum* were also seen at Gudha dam just near Bundi. Similarly dense patches of *O. costatum* were found growing at Ramjhar Mahadev near Bundi.

KOTA—*O. petiolatum* has been recorded for the first time from Bhitaria Kund. *O. costatum* was also recorded from Kanyadeh, Sitabari forest about 120 km east of Kota. Dense patches of *O. costatum* and a few plants of *O. gramineum* were also found at Atru about 100 km. south east of Kota. This is the third locality where the two species grow together.

Aspects of contiguity and intermingling of the different species are being investigated in details in this laboratory.

ACKNOWLEDGEMENT

Thanks are due to Dr. B. V. Ratnam, Principal, Government College, Ajmer for facilities to carry out this survey. University Grants Commission provided financial assistance for this survey.

DEPT. OF BOTANY,
GOVT. COLLEGE,
AJMER,
June 13, 1977.

O. P. SHARMA
T. N. BHARDWAJA
C. B. GENA

REFERENCES

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17. TAXONOMICAL NOTES ON A FEW SPECIES OF *ADIANTUM*

Baker described *Adiantum wattii* Baker (in Jour. Linn. Soc. 18: 381, t. 14 f. A, 1881) based on Watt's collections from Chamba, Pangi, in Western Himalayas and *A. levingei* Baker (in Ann. Bot. 5: 207, 1891) based on Levinge's collection from Sikkim, Chingtang, in the Eastern Himalayas. Beddome in his supplement to the HANDBOOK TO THE FERNS OF BRITISH INDIA (p. 18), 1892, reduced *A. wattii* Baker to a variety of *A. capillus-veneris* Linn. and kept *A. levingei* Baker in synonymy. Hope (J. Bombay nat. Hist. Soc. 13: 240, 1900) while retaining the specific rank of *A. wattii* Baker, also considered *A. levingei* Baker as conspecific and this view appears to have been accepted by all later workers on Indian ferns. On a comparative study of the materials of *A. wattii* Baker and *A. levingei* Baker (isotypes and other materials) housed in the Central National Herbarium, Sibpur, Howrah (CAL), we have come to the conclusion that both are distinct species and can be identified by the following key:—

Sorus oblong or elongate-oblong; pinnule slightly lobed; scale triangular, margin serrulate, base truncate; indusium yellowish when dry ....*A. wattii*
Sorus obreniform; pinnule deeply lobed; scale lanceolate, entire, base rounded; indusium greyish when dry ....*A. levingei*

Available evidence at hand indicates that *A. wattii* Baker is confined to Western Himalayas and *A. levingei* Baker to Eastern Himalayas.

Although we have not seen any type material of *A. refractum* Christ (Bull. Ac. Geog. Bot. Mans. 202, 1902), a study of the description as well as the figure of *A refractum* Christ given by Ching in Icones Filicum Sinicarum (Fasc. 8 : t. 137, 1935) reveals that all the Sikkim materials of *A. levingei* Baker mentioned below are referable to *A. refractum* Christ. Dr. S. C. Verma of the Panjab University, Chandigarh, has also written on the Sikkim sheets previously identified as *A. levingei* Baker) collected by Levinge, present in CAL, as *A. refractum* Christ. If *A. refractum* Christ and *A. levingei* Baker are conspecific the latter name alone should be correct on the basis of priority. Materials examined: (All materials are from CAL unless otherwise indicated).

A. wattii Baker; Cheri, Pangi, Chamba, alt. 7000′, *J. H. Lace* 1876 (Acc. Nos. 41066, 41067), Sept. 1898; Pangi, *J. C. Macdonell* s.n. (Acc. No. 6043), Aug. 1882; Killar-Lahul Road, Chamba, Pangi, alt. 7500′, *James Martin* s.n. (Acc. No. 6042), Aug. 1899.

A. levingei Baker; Chingtang, Sikkim, alt. 3000′, *H. C. Levinge* s.n. (Acc. Nos. 6012, 6013, 6018, 6019, 6024, 6025, 6026, 6032, *H.C. Levinge* s.n. (Acc. Nos. 6014, 6016, 6028, 6033, 6039 *Isotypes*), Nov. 1882; Sikkim, 6029, 6030, 6031), Oct. 1883; *Anonymous* s.n. (Acc. Nos. 6015, 6017, 6022, 6023, 6027, 6034, 6035, 6036, 6037, 6038); Shergaon to Gegaon, Kameng F.D., NEFA, *G. Panigrahi* 15905 (Acc. No. 5462), May 20, 1958, Assam.

A. emarginatum Bory was described in Willdenov's Species Plantarum. (5 : 449, 1810). Hooker (Sp. Fil. 39, 1858) recognised the species. But, its specific status was questioned by later workers. In FERNS OF BRITISH INDIA (1: 18, 1866) Beddome recorded the species from Madras Peninsula based on a collection of Wight. He remarked that, "I have not been fortunate enough to find it unless I have confounded it with *A. aethiopicum*". In his HANDBOOK TO THE FERNS OF BRITISH INDIA (1883) he did combine the two species. C. Christensen (Ind. Fil. 26, 1906) expressed the view that *A. emarginatum* Bory is a variety of *A. capillus-veneris* Linn. To ascertain the taxonomic status of *A. emarginatum* Bory we have taken up a critical study of the species involved and concluded that *A. emarginatum* Bory is a distinct species. A key to distinguish *A. emarginatum*, *A. capillus-veneris* and *A. aethiopicum* is provided below.

Sori oblong:
  Fronds membranous; pinnules obcordate, cuneate, sinus shallow, sorus covering the entire breadth of the lobe..........*A. emarginatum*
  Fronds not membranous; pinnules ovate or triangular, sinus deep, sorus covering only the middle part of the lobe. ......*A. capillus-veneris*
Sori reniform or obreniform ....*A. aethiopicum*

Material examined (The specimens are from CAL).

Malacca, *Anonymous* s.n. (Acc. No. 6053); Malaya, *Anonymous* s.n. (Acc. No. 6052), 1879. On the Malaccan sheet, Beddome has written that "This Malaccan plant is *A. emarginatum* Bory as referred by Hooker".

Of the three species involved here only *A. capillus-veneris* appears to be present in India.

Plants hitherto reported as *A. aethiopicum* Linn. from India are *A. thalictroides* Willd. (*See* Nair and Ghosh 1975). The presence of *A. emarginatum* Bory in India is also doubtful since we could not come across even a single specimen from India in CAL as well as in the various regional herbaria of the Botanical Survey of India.

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S. R. GHOSH

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Indian Botanic Garden,
Sibpur, Howrah-711 103,
May 20, 1978.

REFERENCE

Nair, N. C. and Ghosh, S. R. (1978): Does *Adiantum aethiopicum* Linn. exist in India? *J. Bombay nat. Hist. Soc. 75* (1): 244-247.

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18. ADDITIONS TO THE FLORA OF BIHAR AND ORISSA-II

The 10 species of plants reported in the paper as new records for Bihar and Orissa, were collected by the authors during botanical collections in Ganjam, Bhubaneswar, Barang, Dhenkanal, Bhitarkanika and tidal forests of river Brahmani in Orissa.

Cyperus pubisquama DC.

Ganjam: Paniganda, in forest, fr. 27.i.75. *Saxena & Brahmam* 1933.

Bhubaneswar, occasional in scrub forest, fl. 25.vii.74. *Brahmam* 1933.

Dhenkanal: Saptasajya forest, fr. 23.i.76. *Saxena* 2111.

Distribution: From Assam and Burma to Perak—Malay Islands and Sri Lanka.

Fimbristylis polytrichoides Vahl

Cuttak: Bhitarkanika, common in saline soil, fl. 8.iii.75. *Saxena & Brahmam* 1686.

Distribution: From Bengal to Sri Lanka and Malacca, common near the sea.—Tropics of the Old World.

Hydrocera triflora (Linn.) W. & A.

Cuttack: Barang, aquatic, fl. and fr. 13.vii.75. *Saxena* 1774.

Distribution: Throughout Bengal, the Eastern and Western Peninsula, Sri Lanka and Burma.—Java.

Jatropha glandulifera Roxb.

Bhubaneswar: Kedargouri, fl. 4.iv.75. *Saxena & Brahmam* 1746.

Distribution: Deccan Peninsula from the Konkan southwards; Sri Lanka.—Tropical Africa.

Momordica cochinchinensis (Lour.) Spreng.

Bhubaneswar, rare under tree shade, fl. 1.viii.75. *Brahmam* 1780; *Saxena & Brahmam* 1787.

Distribution: Assam, Bengal, North West Frontier Provinces, Peninsular India, Andamans, Burma, Malaya.—China.

Mucuna gigantea DC.

Tidal forests of Brahmani, fr. 9.iii.75. *Saxena & Brahmam* 1694.

Distribution: Sundribans, plains of Western Peninsula, Andamans; Malaya—Philippines, Polynesia.

Oldenlandia biflora Linn.

Bhubaneswar: Kedargouri; on moist shady walls, fl. and fr. 4.iv.75. *Saxena & Brahmam* 1732.

Distribution: Plains districts of the eastern and western coasts; Karnataka; Sri Lanka.

Neopeltandra suberosa (Muell.-Arg.) Gamble

Cuttack: Barang, roadsides, fl. 23.v.76. *Saxena* 2319.

Distribution: Deccan Peninsula; Samalkota.

Pittosporum nepaulense (DC.) Rehder & Wilson

Ganjam: Koinpur, in the mixed forest, fr. 3.xi.73. *Saxena* 1228.

Local name: Prushparni.

Distribution: Along the foot of the outer Himalayas in Assam, Bhutan, Tibet, Sikkim and Nepal.

Sphaeranthus africanus Linn.

Cuttack: Dangmal, in open grass ponds near rice fields close to river Brahmani, fl. 8.iii.75. *Saxena & Brahmam* 1651.

Distribution: Plains of Bengal and Silhet and southwards to Sri Lanka and Malacca.—Persia, Africa, Malay Islands, China, Philippines and Australia.

ACKNOWLEDGEMENTS

We are grateful to Prof. P. K. Jena, Director, Regional Research Laboratory, Bhubaneswar and to Dr. P. K. Dutta, Project Coordinator for facilities and to the Director and staff of the Botanical Survey of India, Howrah for their cooperation and the facilities provided for consulting the Herbarium.

REGIONAL RESEARCH LABORATORY,
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May 5, 1977.

H. O. SAXENA
M. BRAHMAM

19. NOTES ON DISTRIBUTION OF SOME PLANTS

During a recent botanical exploration tour to Kameng District of Arunachal Pradesh I came across several plants which do not seem to have been reported so far from Arunachal Pradesh. Some of them are of economic importance, and hence it is considered useful to notify their occurrence in Kameng. The specimens are deposited in the Herbarium of Botanical Survey of India at Shillong. As the description of the plants are available in floras no detailed description are provided here. Only a brief note on habit or habitat is given.

Cymbopogon flexuosus (Notes ex Steud.) Wats. var. **sikkimensis** Bor, is an aromatic white-stemmed grass known as "Lemongrass". It has so far been known from Sikikim. The present collection was made from Tenka valley in Kameng District.

Loc: Tenga Valley, 31.8.76, *Hajra* 68539.

Cymbopogon khasianus Stapf ex Bor, is another aromatic grass which has so far been known from Khasi Hills, Naga Hills and Manipur. The present collection from Lumla and Tenga valley of Kameng District extends its distribution further northwards into Eastern Himalayas in Arunachal Pradesh.

Loc: Lumla, 24.8.76, *Hajra* 68505; Tenga valley, 31.8.76, *Hajra* 68538.

Cymbopogon martinii (Roxb.) Watson is also an aromatic grass. Though Bor (1960) has mentioned very common in South East Asia in North-eastern India it has so far been recorded from Nagaland and Khasi Hills only. The present collection was made from Tenga valley in Kameng district. The species can be easily identified by the presence of sessile and aromatic leaves. It grows in open places on the hill slopes. The plant yields aromatic oil.

Loc: Tenga valley, 31.8.76, *Hajra* 68540.

Diplomeris hirsuta Lindl. is a ground orchid with white flowers. It has so far been known from Western Himalaya and eastwards to Sikkim and Bhutan. The present collection from Bongleng-Bomja road extends its distribution further in Eastern Himalayas. The plant grows in shady places on moss covered-rocks.

Loc.: Bongleng-Bomja Road, 26.8.76, *Hajra* 68523.

Impatiens amplexicaulis Edgew. is a herb with sessile leaf and small white flowers. It has so far been known from Western Himalaya and Nepal. The present collection from Tawang extends its distribution further to Arunachal Pradesh.

Loc.: Tawang, 15.8.76, *Hajra* 64737.

Nardostachys jatamansi DC. is a herb root stock covered with fibres. It has so far been known from Western Himalaya and Sikkim. The present collection from Mela pass of Tawang sub-division extends its distribution eastwards. It is a valuable medicinal plants.

Loc.: Mela pass, around Tawang, 15.8.76, *Hajra* 64750.

Picrorhiza kurrooa Benth. is another herbaceous plant with spathulate, subradical, serrated leaves and bitter rootstock. It has so far been known from Kashmir to Sikkim. The present collection from Tawang surroundings extends its distribution to Arunachal Pradesh. It is a valuable medicinal plants.

Loc.: Around Tawang, 15.8.76, *Hajra* 64756.

Pinus roxburghii Sargent is a large tree with 3-4 needles. It has so far been known from Kashmir to Bhutan. The present collection from Kameng District extends its distribution further to Arunachal Pradesh.

Loc.: Bomja—Seru Road, 27.8.76, *Hajra* 68518.

Saussurea obvallata Wall. is a herb with membranous uppermost leaves. It has so far been known from Western Himalaya, Bhutan and Sikkim. The plant grows in open places amidst rocks.

Loc.: Mangmagnella, on way to Mela pass. 16.8.76, *Hajra* 64801.

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I wish to thank Dr. S. K. Jain, Deputy Director, Botanical Survey of India, Eastern Circle, Shillong for kindly reading through and suggesting improvements.

BOTANICAL SURVEY OF INDIA,
EASTERN CIRCLE, SHILLONG,
March 18, 1977.

P. K. HAJRA

20. DISPERSAL IN SOME LORANTHACEAE OF THE NILGIRIS

The semi-plant parasites of the mistletoe family Loranthaceae, have a dispersal system that in almost all cases is linked up with birds. Loranthaceae has a world wide distribution and in different regions, different birds, or families of birds, play a significant role in the propagation of this parasite. Most of the birds that feed on mistletoe berries are unspecialised frugivorous birds. Certain avian families have evolved a mutual interdependance with this plant. Significant among them is the Old World flowerpeckers, Dicaeidae, a family recognised to have a close relationship with the family Loranthaceae as dispersal agents as well as pollinators.

I was able to make some observations on the dispersal of the various species of loranthus in the Nilgiris. The mode of dispersal of the loranthus by the flowerpecker (*Dicaeum* spp.) is well documented by Rumphius (1747)*, Keeble (1901), van Heurn (1922)*, Ali (1931) and Doctors van Leeuwen (1954). The sticky seed surrounded by the viscous matter is swallowed and the rind-like epicarp is discarded. The seeds are soon voided in a string accompanied by some comical acrobatics by the bird. The seeds stick on to or along a branch or twig and germinate. Ali (1931) observed the thickbilled flowerpecker (*Dicaeum agile*) follow a different technique in dispersing the seeds. According to him the flesh is teased out by revolving the fruit in the mandibles of the bird, and consumed, while the seed is rubbed off onto a branch. Doctors van Leeuwen (1954) do not accept this method of dispersal by the flowerpecker. According to Weeraratna (1960)* in Ceylon, the flowerpecker is only interested in the pulp of the berry and the seed is swallowed only occasionally.

In the Nilgiris nearly all the species of loranthus were found to be dispersed by the first method, usually by *Dicaeum concolor*, the most common species of flowerpecker in the hills. Whether passage through the alimentary canal of the flowerpecker improves the germination potential of the loranthus berry is an open question. Seeds of many of the species of loranthus in the Nilgiris seem capable of germinating without having passed through the alimentary canal of the bird. However, in certain species like *Dendrophthoe neelgherrensis* passage through the bird's intestine seems to greatly facilitate germination, as the turbid flesh coating the seed is removed. Keeble (1901) noted that in small seeded berries like *Helixanthera hookeriana* (in Ceylon), the soft seed got partly digested in the alimentary canal of the bird. This was not found to be the case in *H. hookeriana* in the Nilgiris.

The two species of *Macrosolen* in the Nilgiris are dispersed by different methods. The berry of *Macrosolen* differs from *Helixanthera, Taxillus, Scurrula, Helicanthes* and *Dendrophthoe* in having a mass of viscid tissue at the pole opposite the radicle, near the base of the fruit: whereas in the other species the viscid tissue is at the radicular pole of the seed (Kuijt 1969). The viscid tissue in *Macrosolen* forms a sticky 'tail' and is distinct from the fleshy layer which adheres to the epicarp. Ali (1931) noted that *Dendrophthoe falcata* had two thread like viscid processes one at each end of the seed which helps it to adhere along its length to the substrate. In *Macrosolen* the viscid tail at one end of the seed and attaches it at an angle to the substrate.

The fruiting of *Macrosolen parasiticus* a higher elevation loranthus, is from October to May. The fruit has a very thin epicarp and a large amount of fleshy tissue adhering to it. The width of the fruit is 8-10 mm, and assumes a deep bottle green colour when ripe. In this area the flowerpecker appears to have little to do with its dispersal. The large amount of fleshy tissue adhering to the epicarp, and the size of the fruit possibly makes it difficult for the flowerpecker to consume in its usual fashion. Birds observed feeding on the fruits were *Pycnonotus jocosus, P. cafer, Hypsipetes madagascariensis* and *Megalaima viridis*. These birds swallowed the fruit whole and excreted the undamaged seeds singly with the slimy tail retained. The slimy tail got caught on to a substrate and attached the seed to it. Thus in the Nilgiris it was observed that the unspecialised frugivorous birds contributed to the dispersal of *Macrosolen parasiticus.* In Ceylon, Keeble (1901) noted that whole berries of *M. parasiticus* were found in the stomach of frugivorous birds, whereas the flowerpecker stomachs contained only the flesh of the berry and an occasional seed. Possibly the birds had consumed the flesh and rubbed off the seed onto a branch.

In *Macrosolen capitellatus,* a species common on the slopes of the Nilgiris upto an elevation of 1500 m, the fruit is dispersed by the flowerpecker by a different technique. The fruit in this case has a thick epicarp and its width is 8-9.5mm. The species of flowerpecker observed feeding on these berries was *Dicaeum concolor,* the common flowerpecker in this area. The bird plucked off a berry from the clump and flew with it to a bare branch or twig. The stalk end of the berry was held in its bill, the seed was squeezed out and the flesh eaten by manipulating the berry in its mandibles. After the flesh was removed the epicarp was discarded and the seed which was stuck onto one side of the birds bill was rubbed off onto a branch. This exercise takes the birds about 45-60 seconds. Eight *D. concolor* were observed for over an hour on 17 clumps of *M. capitellatus* which were parasitising a *Ficus* sp. Observations were also made in different places and in all cases *Dicaeum concolor* was found to eat the berry in this manner. With other species of loranthus this bird employs the ordinary method of feeding. The feeding method of *D. agile* appears to be similar to the one described above, though I have not been able to make observations on *D. agile* feeding. It would be of interest to know whether the technique of the bird varies with the fruit encountered (as in *D. concolor*), or if a technique is specific to a species of bird. More information on the dispersal systems of the different species of loranthus in India would certainly be useful.

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* Not referred to in the original.

21. A NOTE ON SOME ENTOMOGENOUS FUNGI ATTACKING PRESERVED DRAGONFLY COLLECTIONS

INTRODUCTION

Fungi are the biggest hazard to insects in preservation cabinets. Several instances of fungal attack on preserved and stored insect material have been reported earlier (Wegstaffe & Fidler 1955; Oldroyd 1963; Ray Chaudhuri *et al.* 1975). It seems, useful to give a brief account of atleast some of the fungi which commonly attack dragonflies dry-stored in collection cabinets and the methods to be effectively used to prevent their appearance within the containers.

OBSERVATIONS

No less than six different species of fungi were obtained on an examination of about 100 dragonfly specimens of either sex and belonging to four (two zygopterans and two anisopterans) species namely *Prodasineura autumnalis, Rhinocypha quadrimaculata, Trithemis festiva,* and *T. aurora.* The fungus species as recorded on these dragonflies are *Entomophthora destruens, Entomophthora* sp., *Mucor* sp., *Spicaria* sp., *Tarichium* sp. No. 1 and *Tarichium* sp. No. 2. The six fungi species are new records as far as their host materials are concerned. It is interesting to note that no two different species of fungi have ever been found together on any individual host, however, the same saprophytic fungus may be found on individuals of many species also.

It was found that the organs and parts usually subject to fungal attack were comparatively feebly chitinized and/or membranous, e.g., intersegmental membranes of the abdomen. Body pores and genitalia were, however, among the worst affected parts. As a result of such infestation the material becomes brittle losing many parts of taxonomic significance.

CONTROL

The following control methods could be of great use in coping with the fungal growth on dry preserved material in collection cabinets.

1. Drying of the material in the hot sun for atleast six hours for a week.
2. Spraying of powdered Para dichlorobenzene and/or naphthalene along the inner walls of the box.
3. Putting rolls of cotton soaked in Ethyl acetate in the corners of the box.
4. When the infestation is heavy and apparent the specimens can be cleaned by brushing out with a solution of glacial phenol in benzene in the ratio 1:10 or in dilute formaldehyde.
5. The best method to prevent the occurrence of fungus is to put a ball of cotton wool (about an inch in diameter) soaked in carbolic acid and then placing it on a stout pin. When the acid is recrystalized on the cotton wool, then the ball can be pinned in the drawer.
6. Damp and consequent moulds can be checked to some extend by placing a small perforated tin box containing silica jel in each drawer.

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2. The MS. should be typed (double spacing) on one side of a sheet only, and the sheets properly numbered.

3. All scientific names to be printed in italics should be underlined.

4. Trinomials referring to subspecies should only be used where identification has been authentically established by comparison of specimens actually collected.

5. Photographs for reproduction must be clear and show good contrast. Prints must be of a size not smaller than 8.20 × 5.60 cm (No. 2 Brownie) and on glossy glazed paper.

6. Text-figures, line drawings, and maps should be in Indian ink, preferably on Bristol board.

7. References to literature should be placed at the end of the paper, alphabetically arranged under author's name, with the abridged titles of journals or periodicals underlined (italics) and titles of books *not* underlined (roman type), thus:

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Prater, S. H. (1948): The Book of Indian Animals. Bombay. Titles of papers should not be underlined.

8. Reference to literature in the text should be made by quoting the author's name and year of publication, thus: (Banerji 1958).

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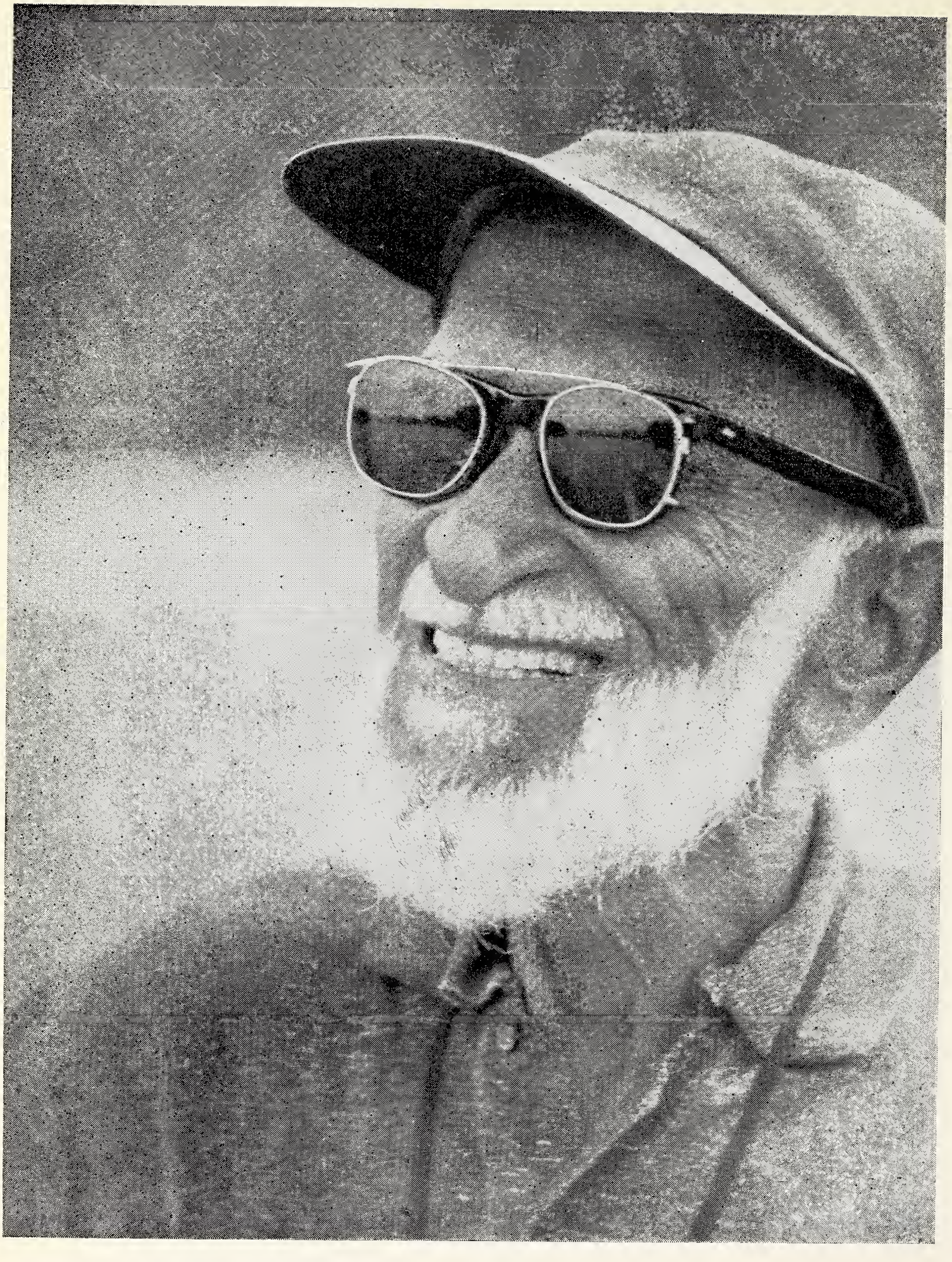

Sálim Ali at Ranganathittu bird sanctuary, 17th June 1974. In his glasses are reflected the islands on which breed 11 species of waterbirds. Dr. Sálim Ali discovered this heronary during his Mysore State survey and was responsible for having it declared one of the first bird sanctuaries in India.

PREFACE

SÁLIM ALI, NATURALIST EXTRAORDINARY: A HISTORICAL PERSPECTIVE

INTRODUCTION

The papers in this issue were presented as a tribute to Dr. Sálim Ali at a symposium on 'Ecology and Conservation of Birds and Mammals in India' held at Bangalore on 11th-13th November, 1977. The authors of these papers represent amongst themselves a majority of scientific workers active in this area on the Indian sub-continent. Notably enough, most of us have been attracted to the field because of Sálim Ali; and his pervasive influence will be apparent throughout this volume. It is therefore appropriate to pause and enquire here into the reasons why this one man has accomplished so much for the scientific study of natural history and for the conservation of nature on the Indian sub-continent.

MAN THE HUNTER

Man has always found fascination in the world of plants and animals around him. In early days his very existence depended on gathering fruits and leaves of the plants and hunting animals for their meat. As a ground dwelling predator of the tropical savannas his most prized prey were the bigger birds and mammals, and the bigger mammals were also his arch-enemies (Ardrey 1976). An intimate knowledge of the habits of these animals must therefore have been a matter of life and death to the early man. From what we now know of the hunting gathering people of today, this knowledge was remarkably detailed and accurate. Moreover, it must have been very systematically organized, and man's capacity for deductive reasoning may, in fact, have originated in his attempts to deduce vital facts about the prey he was hunting from the subtle tracks that were left behind (Blurton-Jones *et al.* 1976).

The fantastic growth of man's intellect enabled him to become a highly successful hunter, a little too successful in fact for the natural resilience of his prey populations to suffice to maintain themselves before the onslaught of man. Starting with the pleistocene, man began to wipe out species after species of the bigger herbivores that were his preferred prey; a process that continues to this day (Mosimann and Martin 1975). With these extinctions came an understanding of the necessity to practice some prudence, and the primitive hunter gatherer seems to have initiated a whole gamut of conservation measures. Taboos against the hunting of pregnant females, and against the hunting of totemic animals must have been components of such conservation measures (Harris 1977). Vālmiki's vehement protest against the killing of a mating crane with which the epic Rāmāyaṇa begins perhaps symbolises the awakening of this consciousness in India.

Beginnings of Agriculture

But the prudence was often ineffective, and man destroyed his very base of subsistence as a hunter-gatherer through over-exploitation in many parts of the world. He then turned to domestication of animals and cultivation of plants—an intensification of resource use which enabled him to build up his populations to ever higher levels (Harris 1977). This process seems to have begun in India some four to five thousand years ago, with hunting-gathering gradually giving way to animal husbandry and agriculture. This transition made possible an accumulation of a surplus of animals on hooves or of grain and initiated the process of social stratification. An accurate prediction of seasonal changes is vital to the practice of agriculture and this promoted the growth of a specialized priestly class of Brahmins (Kosambi 1970). These became the men of learning and made important contributions to mathematics and astronomy on which the predictions of the seasons were based (Bernal 1939).

But these men of learning were cut off from the hunting gathering peoples of our country who continued to nurture the traditional knowledge of animals and their ways and maintain the practices for the conservation of wild animal and plant wealth based in the various taboos. It has been suggested that there was however another tradition of scientific enquiry which did retain contacts with nature, this was the so-called Tantrik-Lokayat tradition (Chattopadhyaya 1978). The Lokayatis worshipped *prakriti* or nature and were perhaps the people responsible for the flowering of Indian medicine and surgery in the first millenium of the Christian era in India.

Loss of Contact with Nature

The pressures on land had been building up all this time and by the time of Buddha around 600 B.C. there were no more large herds of animals to permit continued large scale animal sacrifice as a part of religious ritual. The cattle in particular were extremely valuable as a source of power for agriculture which had now spread over vast stretches of the country and the cattle had to be conserved. Over the next fourteen hundred years therefore there was a protracted struggle to abandon cattle sacrifice at religious rituals ; a struggle that ended in the cow becoming a holy animal never to be killed and with the Brahmins abandoning all eating of meat, except in a few instances (Kosambi 1970, Harris 1977).

With this adoption of strict vegetarianism, the Indian men of learning in the Brahminical tradition lost all contact with the way of life that demanded an intimate knowledge of animals for successful survival. At about the same time around 800 A.D., the Brahminical tradition also succeeded in largely suppressing the intellectual tradition of the nature worshipping Lokayat school (Chattopadhyaya 1978). With this ceased further progress in medicine and surgery ; and after this there were no more great poets like Kalidasa dealing lovingly with mountains and forests and wild animals.

MUGHAL NATURALISTS

The only segment of the Indian social elite retaining any live contact with nature over the mediaeval times has been the princes, both Hindu and Moslem. The princes have always been devoted to hunting, andthe Kautilya's ARTHASASTRA, for instance, gives detailed instructions on the maintenance of hunting preserves and elephant forests. But it was the Mughal emperors who seem to have taken a more seriously intellectual interest in this pastime, and Jahangir is famous for his collection of animals and their paintings, and for his own perceptive observations on the habits of animals (Alvi and Rahman 1968). But these scientific enquiries of Jahangir were outside the main stream of Indian intellectual tradition.

TRIBAL NATURE LORE

This has gone on now for over a thousand years and we have a dual society. A small but significant fraction of the Indian population still depends on wild plants and animals and still retains a tremendous storehouse of traditional knowledge of animals and their way of life. I know this, for instance, to be true of the Phaseparadhis of Maharashtra and the Kādu-kurubas of Mysore (Khomne *et al.* 1980). But the formal body of learning does not recognise this as knowledge and treats it as being worthless. Thus a zoologist like me is forced to pay an assistant with this body of knowledge so important to my work at the same level as a totally unskilled worker, while an assistant with a formal degree but no real knowledge or understanding of animals must be paid several times higher wages. This same segment of society in intimate contact with the nature also has a whole series of nature conservation measures which have been responsible for preservation of much that we are now beginning to treasure. Here again, this traditionally preserved wealth, as for instance embodied in the sacred groves, is being destroyed by the civilised society, while it is creating its own nature reserves which end up being protected only on paper (Gadgil and Vartak 1975).

CONTACT WITH WESTERN SCIENCE

Thus we have a picture of the Indian civilization almost totally cut off from live contact with nature. When this civilization came in contact with the Western science, it developed a tradition of teaching and research in zoology based entirely on the study of dead animals in the laboratory. It was also a civilization utterly indifferent to an ever accelerating and tragic loss of its magnificent heritage of plant and animal life.

In this mileu was born a remarkable man ; Sálim Moizuddin Abdul Ali in the year 1896, and he became the foremost heir in the modern times to the great tradition of natural history that flourished in the courts of Mughal emperors. Notably enough, some of the most interesting early papers of Sálim Ali are on Mughal emperors as naturalists (Ali 1927-28). He also imbibed the tradition of natural history brought to India by the British naturalists. Quite naturally he did not care much about the formal study of dead animals that went on in our institutions of learning and struck out his own path without ever obtaining a formal degree. He wrote two remarkable papers on bird pollination and on the breeding behaviour of baya weaver birds ; work that was way ahead of ecological and behavioural studies not merely for India, but the world over (Ali 1931, 1932). He then launched on his own, without any institutional backing but was supported to a limited extent by the tradition of natural history amongst the princely houses of India. For, a number of native states invited Sálim Ali to undertake ornithological surveys in their territory ; and with these surveys he established a solid basis for the systematic study of Indian birds over the four decades from 1930's (e.g. Ali 1933-34, Ali 1962), culminating in the monumental HANDBOOK OF BIRDS OF INDIA AND PAKISTAN (Ali and Ripley 1968 to 1974).

Like all great naturalists in this tradition he began as a hunter. India has produced many man-eating tigers ; but Sálim Ali is one of its few tiger eating men : he has shot and eaten tiger steak in the old days in Assam. But he was amongst the first to realize the plight of India's wildlife and one of the earliest to begin a battle for nature conservation in India. More than any other man, he is responsible for the present-day consciousness for conservation in our country (Gee 1964).

THE FUTURE

It has been a struggle against heavy odds for him in a society utterly indifferent to natural history and nature conservation. But largely thanks to his efforts we are about to turn a new page. With his handful of students and a few others inspired by him, we are at last beginning to see being established in India a sound tradition of scientific study of living birds and animals, and of a scientifically based conservation effort. Both these traditions are still in their infancy, and it was perhaps due to this that the tribute paid to him on his 75th birthday was largely the handiwork of his foreign admirers. But then we plotted to see to it that when he completes his 81st year at least, the tribute should come from his own country. This dream was realized when a symposium was organized on 11th-13th November 1977 at the Indian Institute of Science in Bangalore to honour Dr. Sálim Ali. The theme of the symposium was the ecology and conservation of birds and mammals in India, and a majority of Indians active in this field gathered together to express their gratitude to the man who began it all. The proceedings of that symposium are this volume, and on behalf of us all, it is my privilege to dedicate it to Dr. Sálim Ali.

MADHAV GADGIL

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Vol. 75 SUPPLEMENTARY ISSUE

ON THE TIME-BUDGET OF DIFFERENT LIFE-HISTORY STAGES OF CHITAL (*AXIS AXIS*)

H. C. SHARATCHANDRA AND MADHAV GADGIL[1]

(*With two plates, four sketches and five text-figures*)

INTRODUCTION

Any animal has to undertake a variety of activities in order to survive, grow and reproduce. A male baya weaver-bird in the breeding season, for example, has to collect nesting material, weave his nest, defend the nesting area against intruding males, display to the attendant females, feed, drink, sleep and so on. Each of these activities has a certain benefit and a certain cost attached to it. Reducing the time spent in feeding may enable a male to complete the nest more quickly and display more towards intruding males and receptive females. However, he may at the same time be exposed to a greater risk of mortality through physical exhaustion. Shifting the emphasis from threatening intruding males to collection of nest material, may allow him to construct the nest more quickly, while at the same time render him more susceptible to the usurpation of his territory. Obviously all these trade-offs have to be balanced for an appropriate decision regarding the proportion of time to be allocated to each activity. The calculation of such trade-offs and hence the appropriate time-budget will depend on the criterion that the animal wants to maximise. We do not of course imply that the animals consciously choose a criterion and then allocate their time amongst various activities through appropriate calculations of cost and benefit attached to each activity. Rather, we make the assumption that the criterion is genetic fitness, and that the natural selection has moulded the time-budget of any animal so as to maximise its genetic fitness.

A study of such time-budgets can be expected to throw much light on how the behaviour of any organism is structured in relation to its ecology. Fagen (1974), for example, has shown that natural selection should favour the allocation of a larger fraction of time towards play activity in the juvenile phases of the life-history. MacFarland (1977) makes a much finer analysis and shows how natural selection moulds the proportion of time devoted to and sequence of the various components of a male newt's courtship display. The whole study of time-budget is, however, in a primitive stage, and very few good time-budgets are as yet available (Wilson 1975). Here we analyse the time-budget of spotted deer or chital (*Axis axis*), a highly social deer species of the oriental region, with particular emphasis on the variation in the time-budget at different stages of the animal's life-history.

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MATERIAL AND METHODS

The Environment:

The observations reported here were carried out on a herd of chital in the vicinity of the lodges at Bandipur Tiger Reserve in Karnataka (11°39′N and 76°37′E). This herd inhabits a very open, dry deciduous forest interspersed with extensive grassy glades. The tree canopy is dominated by *Anogeissus latifolia*, and the shrub layer by *Lantana camara*. The herb layer is predominantly made up of grasses, although there are extensive patches of *Eupatorium* in places. The mean annual temperature of Bandipur is 20°C, and the mean annual precipitation 1000 mm. The dry season when forest fires occur runs from January to March, when the deer consume considerable browse and fruit. Good rains at the onset of south-west monsoon occur in April-May, followed by a relatively dry spell in June. There is a second peak of rainfall in October corresponding to the north-east monsoon, though the rains continue all the way from July to November. The deer largely consume grasses in this wet period.

The Animal:

The chital, with its coat adorned by white spots, is one of the most handsome deer in the world. It is a medium-sized animal, with adult females weighing around 35-45 and males upto 60 kilograms. The large males grow antlers upto 90 cm in length. This animal's attractiveness is greatly enhanced by its social habits, herds of over a hundred animals not being uncommon in the early monsoon season. After September the herds break up into much smaller units, even as small as two or three animals in the dry season in January-March. The rutting season of the deer coincides with the south-west monsoon. This is when a majority of males are in the hard antler stage, and large bisexual herds are formed. Antlers are shed from September to November, and outside of the rutting season the males tend to form small bachelor herds. The males' antlers are largely in velvet in the dry season from December-March, which is the hardest season for the animals; but also happens to be the period when most fawns are dropped (Schaller 1967, Sharatchandra and Gadgil 1975).

Chital is the commonest of the resident larger herbivores of Bandipur Tiger Reserve, a population of about 800 inhabiting an area of 20 square kilometres in the vicinity of lodges in the tourist zone. This population is organized rather loosely in herds which do change considerably in strength and composition over the year. One of these herds spends the night on the lodge grounds and forages during the day-time in the forest to the north of the lodge towards Bolugudda hillock. Its strength over the year varies from 80 in the monsoon season, to around 30 in the driest period. Most of the observations presented here are based on the animals of this particular herd.

The Observations:

We have computed the time-budget of chital on the basis of a recording of behavioural sequences of individual animals. The method followed was to focus randomly on an animal without any bias in respect of an animal indulging in a more conspicuous activity. Having focused on an animal, a record was maintained of the date, time of day, the stage in life-history of the animal, and the number of seconds spent on each activity till the animal went out of sight. The time spent on each activity was recorded with the help of a stop-watch accurate to 0.1 seconds. As soon as the focal animal went out of sight, another animal was picked up, again at random and its behavioural sequence recorded and so on. Over 6500 such behavioural sequences have been recorded over a period of twelve months from October 1975 to September 1976. The observations were restricted to day time from 0530 to 1900 hours. These behavioural sequences were subsequently coded and punched on computer cards. This data was utilized to calculate the time-budget of each life-history stage, and for each season after due corrections for the bias introduced by the fact that observations were concentrated to the dawn and dusk hours when the animals are most active. Here we present the data on the time-budgets of the various life-history stages for the year as a whole.

The Life-History Stages :

While maintaining the field observations, chital were classified into one of the following four major categories and twelve sub-categories :

(1) Juveniles : Immature animals below the age of a year. These were further classified into babies upto the age of 3 months and fawns beyond the age of 3 months (Plate I).

(2) Adult females : These were not classified any further (Plates I, II).

(3) Adult males in velvet : This category included the five sub-categories of shed antlers, and velvet antlered males with antlers less than 25 cm, between 25-50 cm, between 50-75 cm and over 75 cm in length. No particular significance attaches to the antler sizes though as the antlers in velvet continue to grow till the velvet is shed and do not necessarily reflect the ultimate size reached.

(4) Adult males with hard antlers : It is the adult males in hard antlers that are active in social displays, agonistic and sexual activities, and therefore of greatest interest. The yearling males have the so-called spike antlers less than 25 cm in length. Older males have antlers which appear to grow in size with body size. They have been classified in three more categories : antlers between 25 to 50 cm, between 50 to 75 cm and over 75 cm in length (Plate II).

The Activities :

On the basis of our earlier observations at Bandipur from May 1974 to September 1975, we divided the activity pattern of chital into the following 8 major categories, with 29 sub-categories :

(1) Locomotion : Subdivided into (*a*) walking, (*b*) running and (*c*) trotting.

(2) Anti-predatory behaviour : Chital is the major prey species of the three predators of Bandipur—wild dog, panther and tiger, and the deer spends a significant fraction of its time in antipredatory behaviour. The three sub-categories we use are (*a*) standing, scanning for anything suspicious, (*b*) an alert posture with the neck outstretched pointing in the direction of the disturbance and (*c*) giving alarm signals which include tail raising, alarm calls, stamping the ground with forefoot, and when actually confronted with a predator stotting and bunching into a tight herd.

(3) Grooming behaviour includes (*a*) licking itself (sketch 1), (*b*) scratching itself, (*c*) being licked and (*d*) licking another deer. The last two categories involve mother licking her fawn, and a fawn licking its mother.

(4) The trophic behaviour which dominates at all seasons includes—(*a*) scanning for fallen fruit, (*b*) pushing in competition for food items, (*c*) drinking, (*d*) feeding, (*e*) standing and chewing, (*f*) ruminating, (*g*) drinking mother's milk, (*h*) nursing a baby (Plate I).

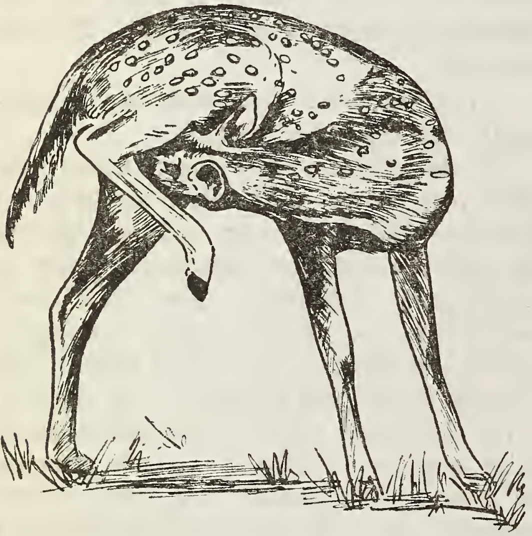
(5) Fighting, which includes pushing and

thrashing with forelegs amongst females (Plate I) and shed antlered males, and sparring with antlers in hard-antelered males (Sketch 2). Butting to initiate a fight is also included.

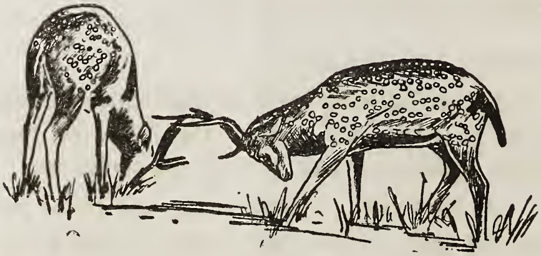
(6) Play, includes the seemingly non-functional vigorous physical activity of the juveniles and yearling males with spike antlers.

(7) Displays : The males, almost exclusively those in hard antlers, indulge in a variety of displays : (*a*) preaching, includes thrashing the vegetation with forelegs while rearing up, (*b*) rubbing forehead and preorbital glands on vegetation (Sketch 3), (*c*) rubbing antlers on vegetation, (*d*) hitting antlers vigorously, generally on a bush, (*e*) giving rut calls. These displays involve a single individual. In (*f*) dominance display, a male approaches another sideways with head held high and to a side (Plate II). The responding male may ignore the challenge, continuing to feed, or whatever else he was doing, join in a sparring bout or respond with a (*g*) submissive display which involves moving off with a lowered head.

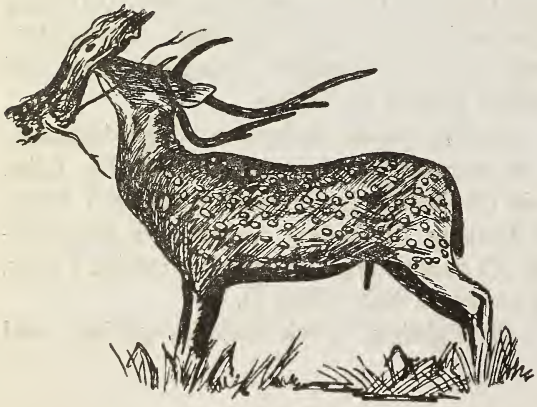
(8) Sexual behaviour includes (*a*) male sniffing at the female's vagina (Sketch 4) and (*b*) mounting another individual. Mounting may involve female-female as well as juvenile-female mountings also, (*c*) the very rare behaviour of a female soliciting (Plate II).



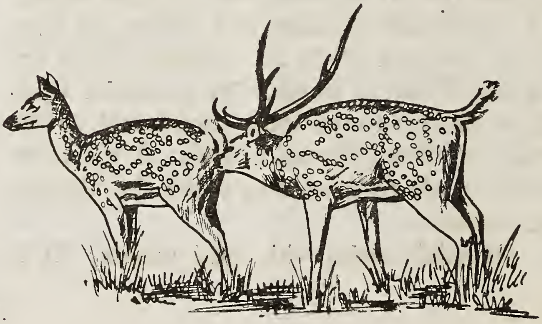
Sketch 1. Grooming : Chital doe cleaning by licking its underparts (after a photograph).



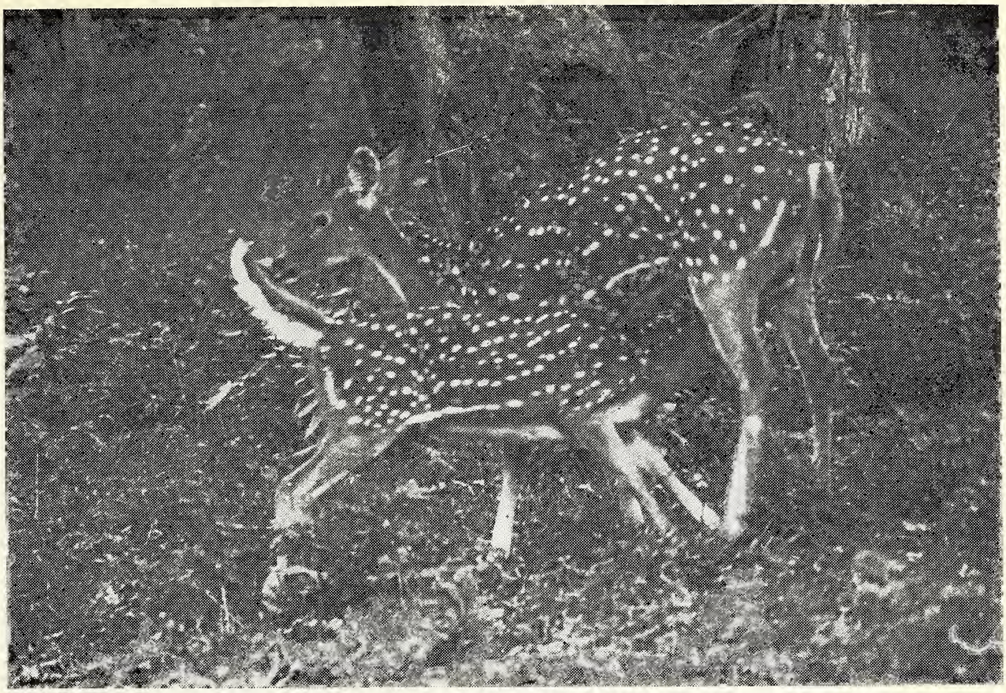
Sketch 2. Sparring match : The males generally spar with other males of the same size class (after a photograph).



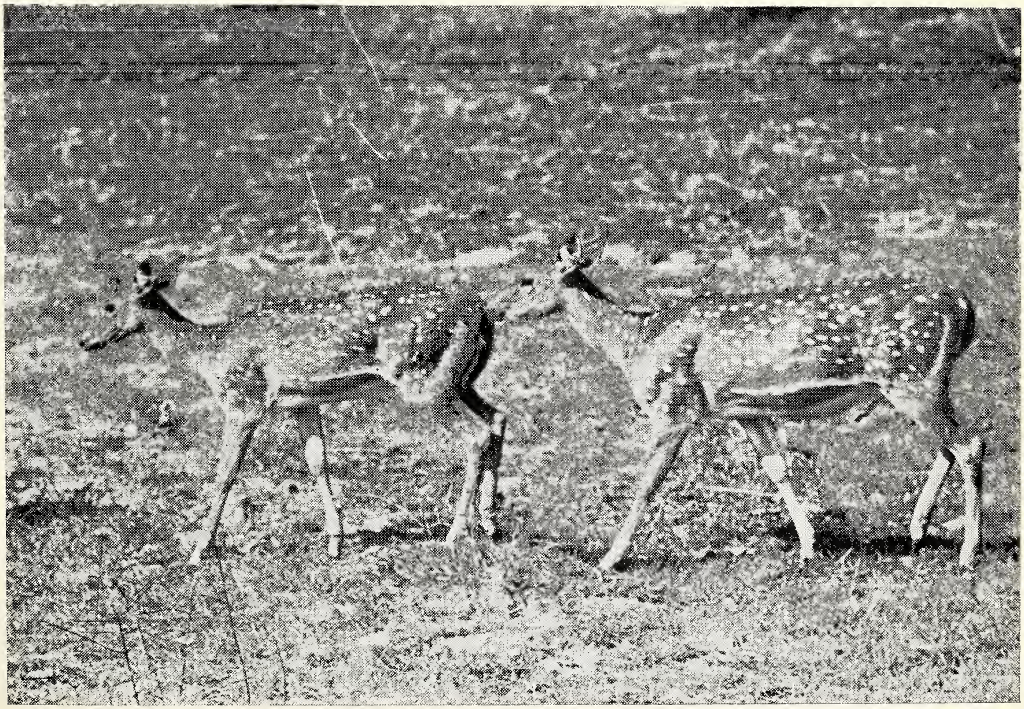
Sketch 3. A chital stag sniffing, after rubbing the preorbital gland on a tree trunk. Note the erection of the penis (after a photograph).



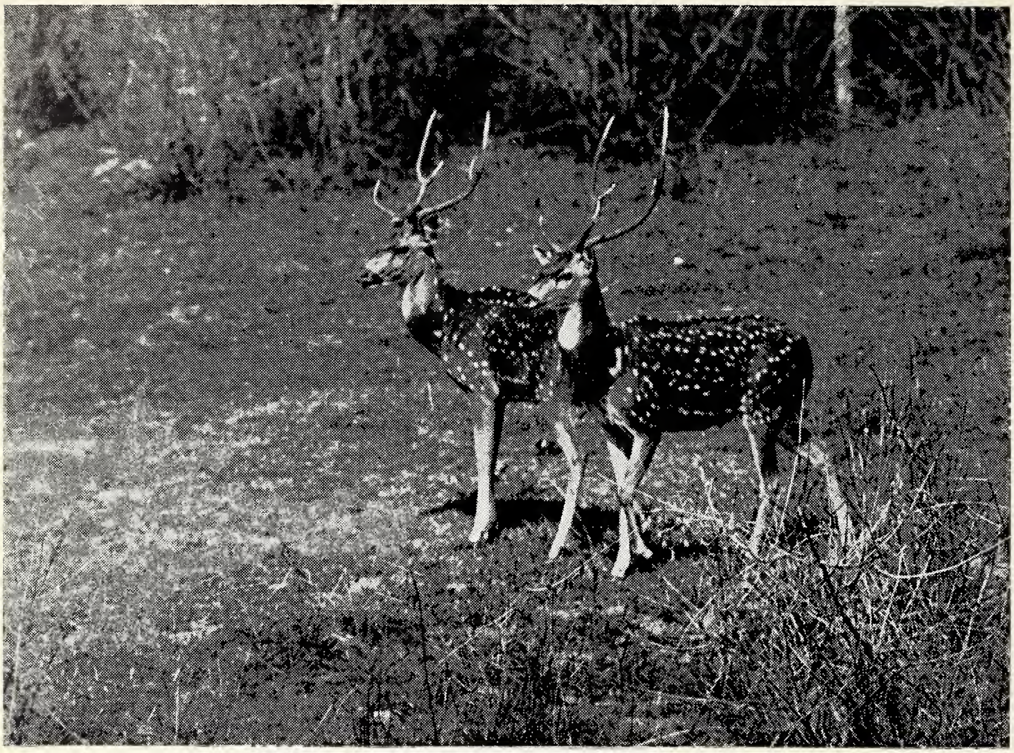
Sketch 4. Chital stag sniffing the vagina of the oestrus doe. Note the submissive posture of the stag (after a photograph).



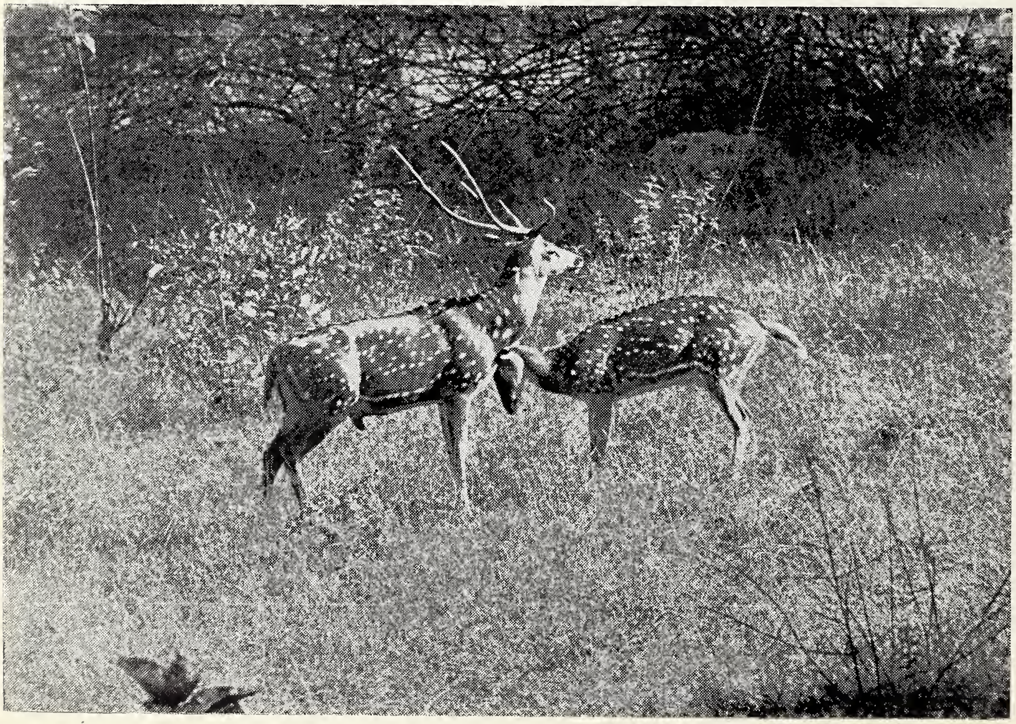
Chital nursing a fawn.



Chital doe pushing another doe.



Stags challenging each other. Note the position and angle at which the neck is held.



Chital doe courting a stag.

RESULTS

(1) Trophic activities occupy an overwhelmingly large fraction of chital's time followed by anti-predator activities, fighting, displays, locomotion grooming, play and sexual activities (figs. 1 and 2).

(2) Males in hard-antlers devote less time to trophic activities, and much more time to display, fighting and to locomotion than the other life-history stages (figs. 1 and 2).

(3) Females devote a greater fraction of their time to anti-predatory activities (fig. 1).

(4) Play is particularly prevalent amongst juveniles and spike males (figs. 2 and 3).

(5) Sexual activities are restricted to juveniles and hard antlered males. Amongst the latter, they are monopolised by males with antlers over 75 cm in length (figs. 2 and 5).

(6) Displays such as preaching, rubbing antlers and hitting antlers are particularly prevalent amongst males with hard antlers between 50 and 75 cm in length (figs. 4 and 5).

(7) Dominance displays are common amongst males with antlers between 25 to 50 cm in length, and over 75 cm in length. Note that the class with intermediate size antlers is notable for lack of dominance displays. At the same time submissive displays are almost restricted to males with antlers over 75 cm in length. Fighting is particularly common in males with antlers between 25 cm and 50 cm and between 50 cm and 75 cm. Pushing is common in males with antlers between 50 to 75 cm in length (figs. 3, 4 and 5).

(8) Sexual activities such as sniffing and mounting are quite common amongst the fawns and as mentioned above, to males with hard antlers over 75 cm in length (fig. 5).

DISCUSSION

Two of these results, namely the greater prevalence of antipredatory behaviour amongst the females, and the distribution of the display, agonistic and sexual behaviour in the various classes of hard-antlered males deserve further discussion.

Antipredatory Behaviour

Chital is a highly social species, and the avoidance of predation appears to be the prime moving cause of its sociality (Hamilton 1971). Field observations on the predation on chital by wild dogs indicate that any animal which strays off from the herd is particularly susceptible to predation (A. J. T. Johnsingh, personal communication). When the predators approach a herd of chital, the deer respond by forming a tight bunch. There is no active defence against the predators, and in fact the stronger males force their way into the centre of the herd. This leaves those animals forced to stay on the periphery, mostly females, much more susceptible to predation, and again Mr. Johnsingh's field data seem to indicate that females do suffer heavier mortality through predation. It would therefore appear that females have been selected to be much more alert, since only through an early awareness of the danger could they stand any chance of getting to the safety of the centre of the herd. The stronger males on the other hand can force their way to the centre of the bunch even if they are alerted a little late, and hence do not allocate as much time to antipredatory behaviour as do females. The juveniles are maximally susceptible to predation, but do not exhibit as much antipredatory behaviour as do the females. Presumably, the juveniles depend on the mothers to be warned of danger, and in fact they always stick to their mothers.

Display, Agonistic and Sexual Behaviour

In chital, as with many other mammalian species, there is evidence that while all females are successful in reproduction, only a small fraction of males monopolises all breeding. Sharatchandra and

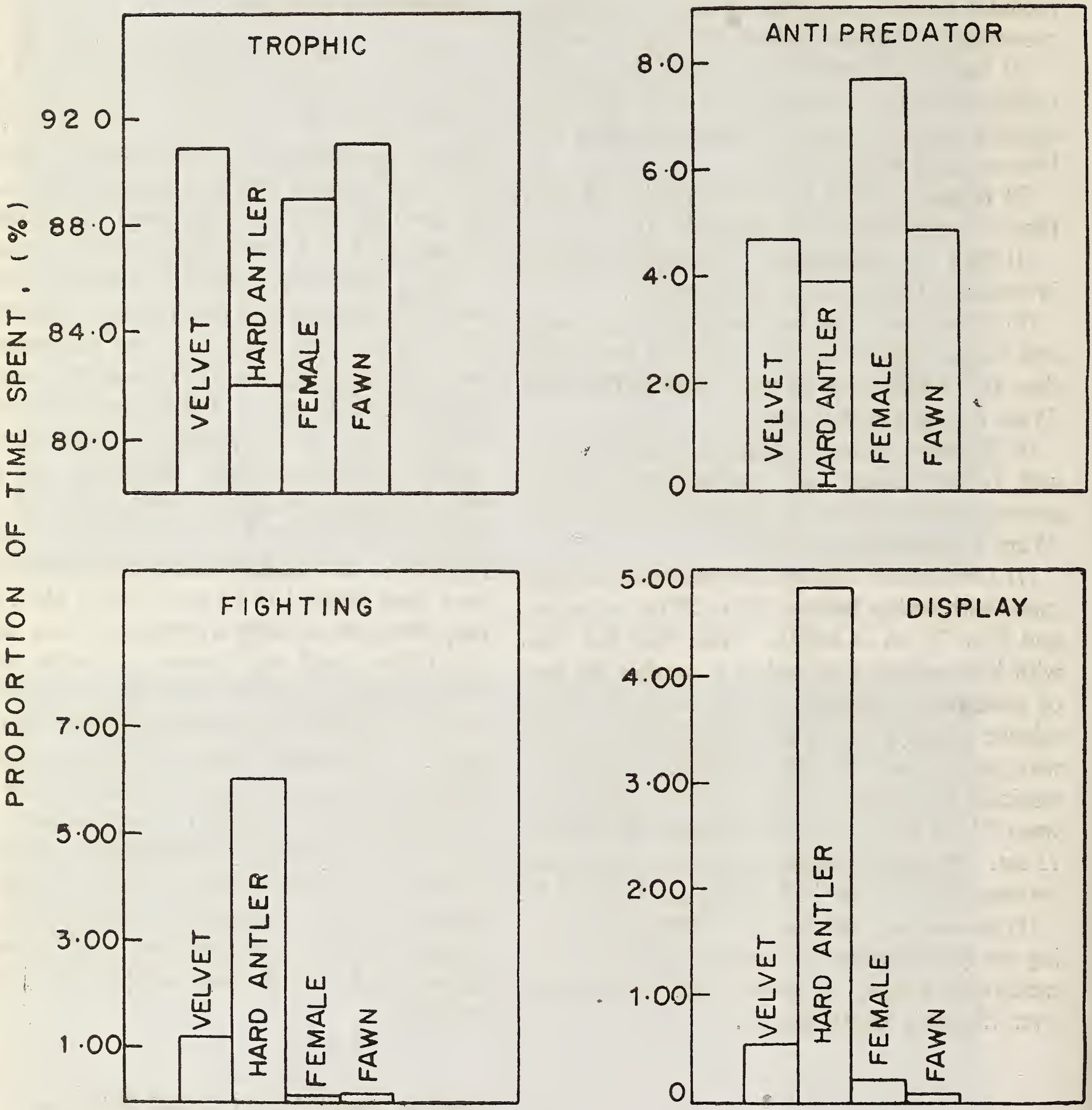


Fig. 1. Histograms showing the proportion of time spent on trophic, anti-predator, fighting and display activities by different life-history stages of chital.

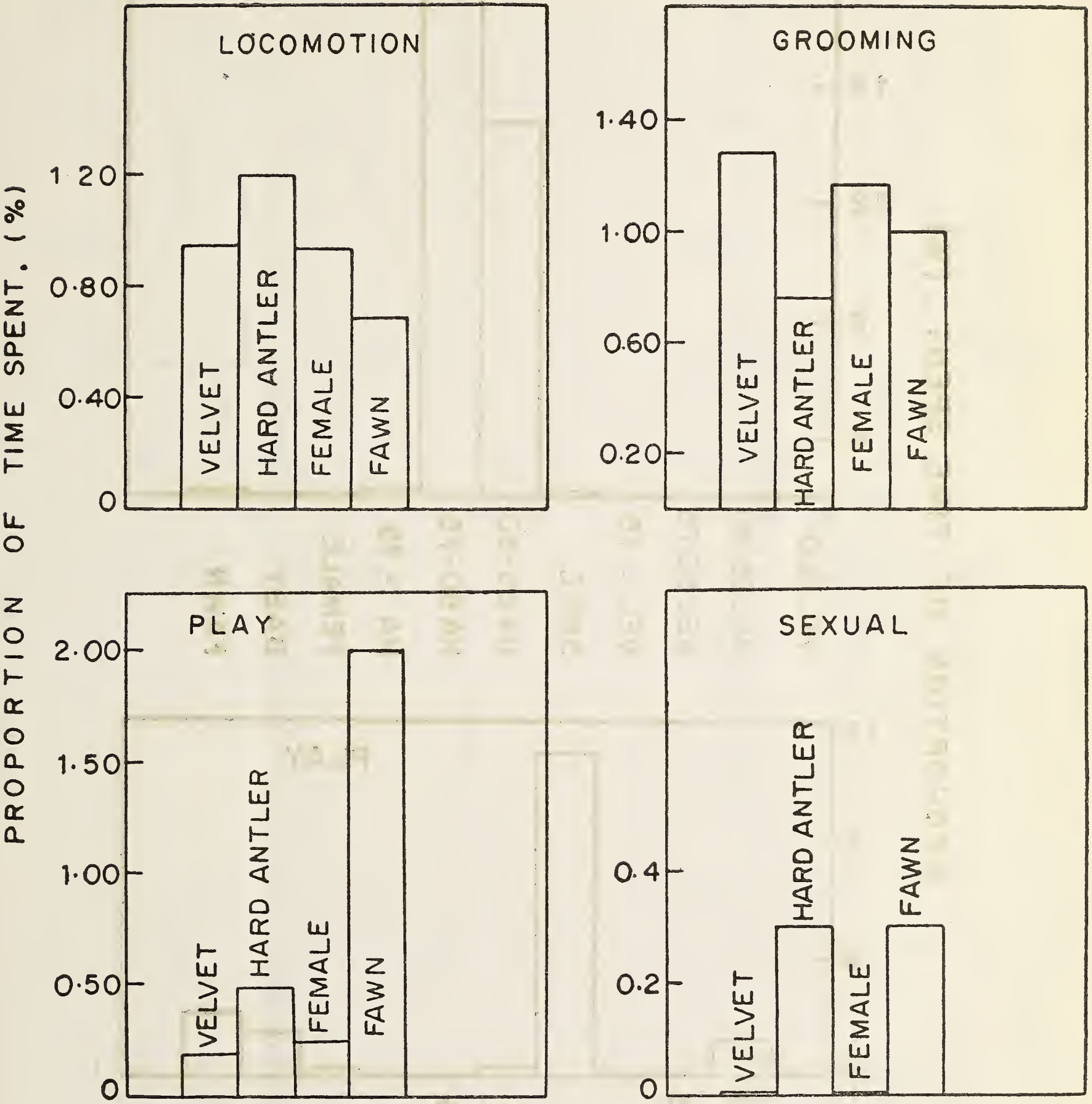


Fig. 2. Histograms showing the proportion of time spent on locomotion, grooming, play and sexual activities by different life-history stages of chital.

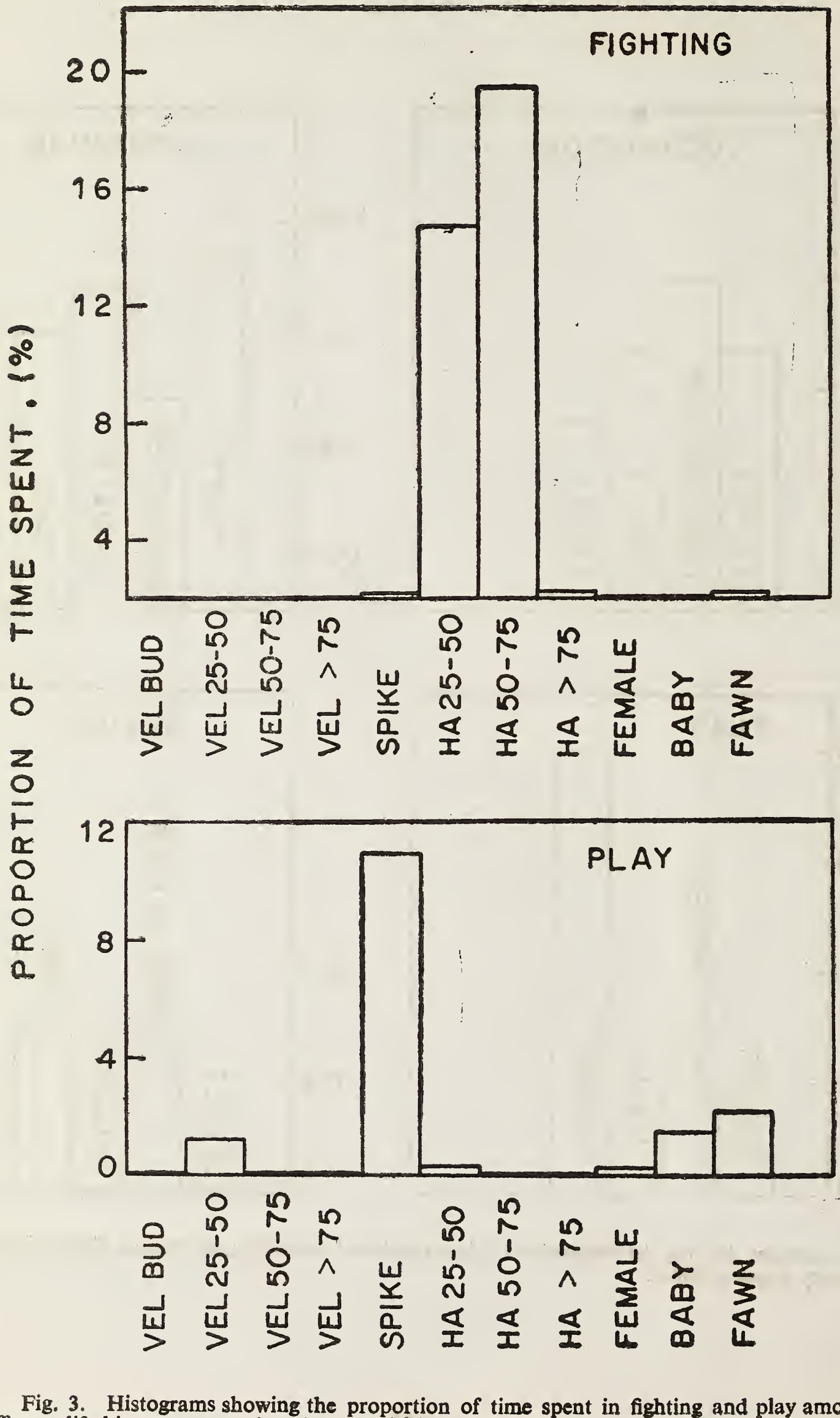


Fig. 3. Histograms showing the proportion of time spent in fighting and play among different life-history stages of males, females, baby and fawn.

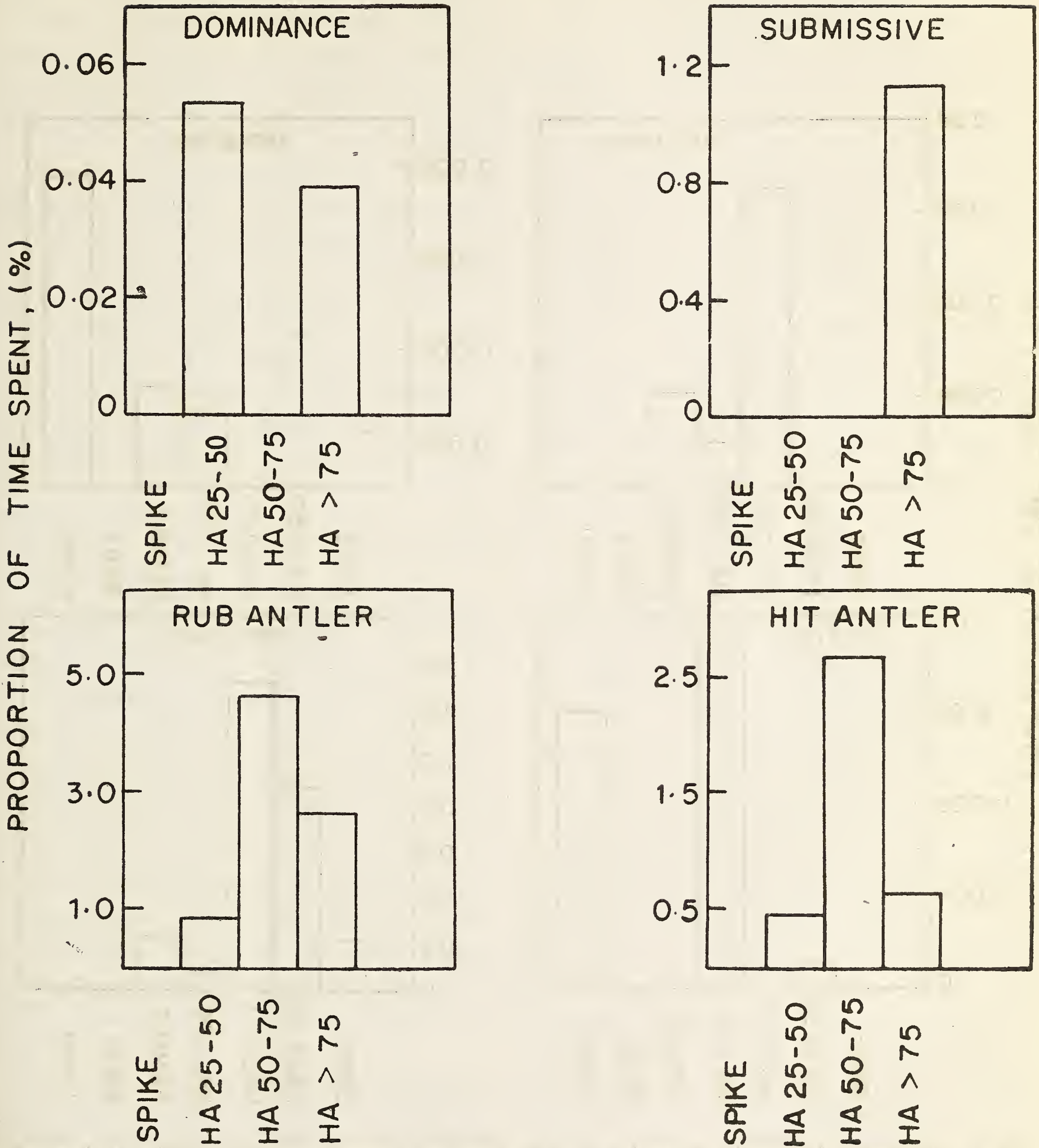


Fig. 4. Histograms showing the proportion of time spent on dominance, submissive, rubbing and hitting antlers among different life-history stages of males in hard antler.

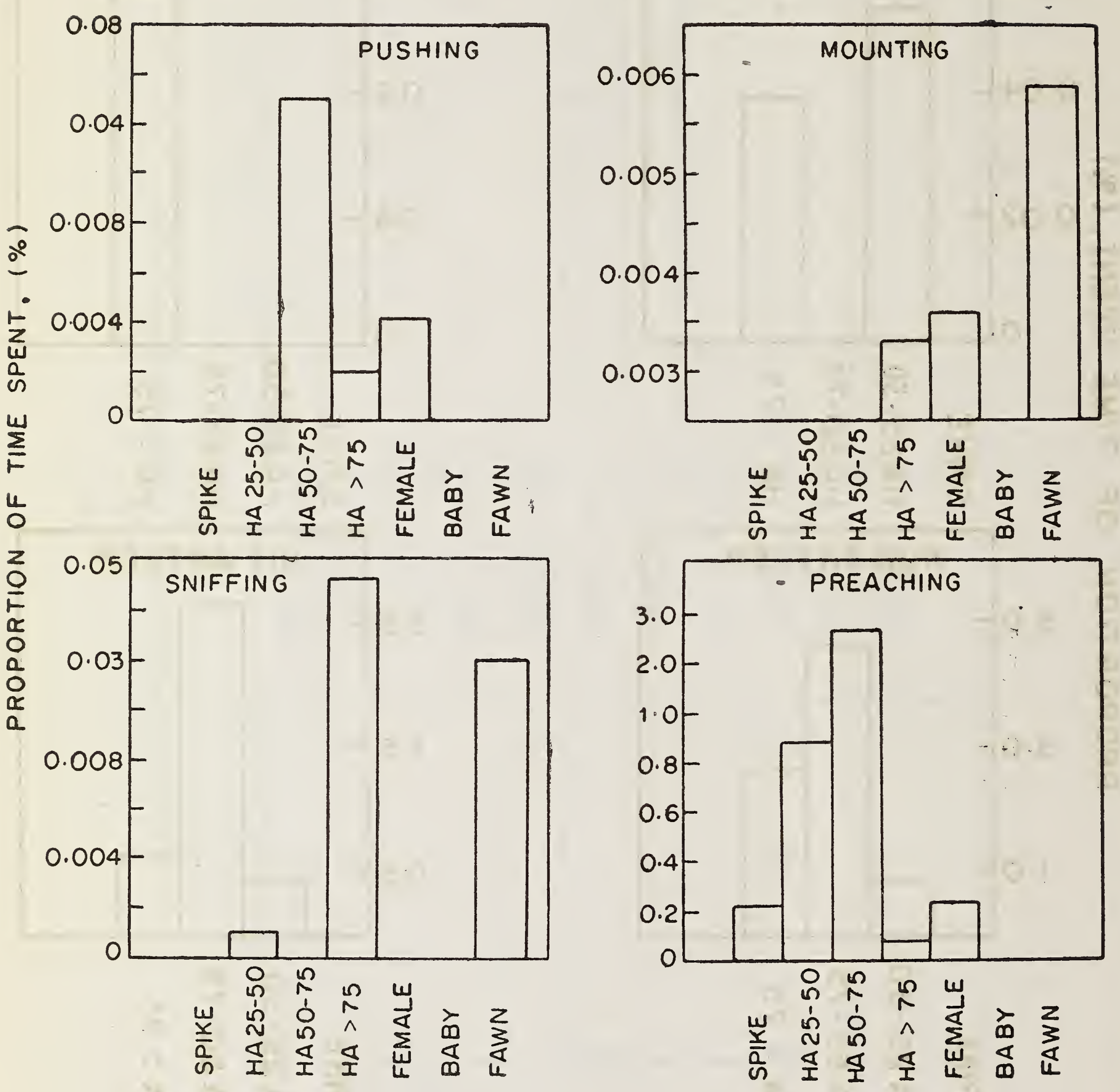


Fig. 5. Histograms showing the proportion of time spent on pushing, mounting, sniffing and preaching activities by different life-history stages of males in hard antlers, females, baby and fawn.

Gadgil (1976) from their earlier study of the dynamics of the chital population of Bandipur conclude that the birth rate appears to be such that all adult females fawn once a year. On the other hand, our present study indicates that only males with antlers over 75 cm have sexual access to the females. It is of course possible that even of the males in this class, not all are successful in breeding. In any case, only a small fraction of males can breed successfully, and as Trivers (1972) points out, this would generate intense selection pressures amongst the male sex to be included amongst the males who are successful in breeding. The tremendously higher level of display and agonistic activities amongst the adult males is clearly related to the male-male competition generated by these selection pressures (fig. 1). As this figure shows males indulge in these activities, particularly when they are in the hard-antlered stage, when antlers can be safely employed in sparring.

The male population is composed of several overlapping age and size classes. The males continue to grow in size for several years, and the size of antlers is positively correlated with body size. As the males approach their prime, therefore, they must slowly grow into the size class which includes the males who succeed in breeding. However, if all males automatically grew to the size at which they are successful in breeding, we would not expect the tremendous investment that the males make in display and agonistic activities. It is likely that the growth rate itself depends on success in competition, and also that not all of the bigger males are equally successful in breeding.

It is evident that all adult males are engaged in a continual struggle, particularly during the breeding season, to succeed in reproduction either immediately, or acquire a size and status so as to succeed in reproduction in coming years. The particular combination of display, dominance, submission and agonistic activities employed by a male can then be assumed to have evolved so as to maximise his chances of doing so.

Our results suggest that the strategy adopted by males to accomplish this changes in a most interesting fashion over the four different antler size-classes. The males with spike antlers are first year males. They engage a great deal in what has been classified as play, and involves jumping around vigorously and kicking with hindlegs in the air. They also do some preaching. Apart from this they do not indulge in any display or agonistic activities. Males with antlers between 25 and 50 cm in length engage to a considerable extent in displays like hitting antlers. They also engage quite a bit in fighting and pushing. The fights are initiated generally by a dominance display which may be ignored or responded to with a fight. There is no submissive display. They may sniff female's vagina, but do no mounting. The male-male competition reaches its highest pitch in males with antlers between 50-75 cms in length. This is the size-class, just below the class which breeds successfully. These males give displays such as hitting antlers maximally. The fighting in this group appears compulsive. The fights are initiated not through dominance displays, but by a direct butt with a lowered head. This invariably leads to a fight. These males however do not get a chance at any sexual activity.

The males with antlers over 75 cm in length are the only ones to participate in sexual activities. They indulge very little in other displays such as preaching and hitting antlers. They are the only class of males to give rut calls. They challenge other males with a dominance display. The challenge is generally responded to by a submissive display, and only in a small fraction of cases does it lead to fighting. Overall it appears as if there is a strong selection against actual fighting, perhaps because the energy cost involved or the risk of injuries is very high, or simply because the hierarchy in this group is rather rigidly established, most fights occurring between males of similar sizes. A more detailed exploration of this shift in strategy of male competition with marked individuals, and a theoretical exploration of how changing selection pressures bring about a change in strategy would be most interesting to pursue.

ACKNOWLEDGEMENTS

We are thankful to the authorities of the Karnataka State Forest Department for their generous co-operation and for the facilities provided that made this study possible. Financial support of World Wildlife Fund—India is gratefully acknowledged. The Centre for Theoretical Studies and the Indian Institute of Science helped us by providing many facilities. Our colleagues S. Narendra Prasad, P. V. K. Nair and A. J. T. Johnsingh have helped in the field work and through many stimulating discussions. Sulochana Gadgil has helped with critical discussions at all stages.

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ON THE PRIMATE RESOURCES OF INDIA

S. M. Mohnot[1]

INTRODUCTION

The greatest concentration of primate species of the world lies in the Indian region. These species range from a squirrel like tree-shrew to a large gibbon. Eight genera having 18 species and 44 subspecies (one third of the world total of 130 subspecies) are found in India. Of these, 7 species, *Anathana ellioti*, *Tupaia nicobarica*, *Macaca assamensis*, *M. radiata*, *M. silenus*, *Presbytis geei*, and *P. johnii* are exclusively Indian in their distribution. However, very little work has been done on these species in nature except on *M. mulatta*, *M. radiata*, *P. entellus* and *P. johnii*. Even the exact range of distribution and present population status of most of our species is still not known. The large scale destruction of primate habitats (mainly forests) is going on uninterrupted in most parts of the country resulting in population depletion, because of ecological vulnerability of most of the species. Some of them have even reached the level of extinction—a clear cut case of human predation. The rhesus macaque is the biggest sufferer due to the destruction of their habitats and large scale harvest for export. The rhesus population has thus declined considerably in the recent past.

In addition to the above, a serious problem linked with the use of the rhesus abroad has also come to light. The export of these monkeys is allowed on a clear understanding that these monkeys will not be utilized for any other purpose than 'biomedical'. Indeed, they have been increasingly used in chemical-biological warfare experiments by the importing countries.

The present paper deals with some of the urgent problems associated with the Indian non-human primates and likely solutions keeping in view the increasing use of monkeys in different researches and the present supply position.

PRIMATE STOCK IN INDIA
(Table 1)

Of 18 non-human primate species occurring in different parts of the country (Roonwal and Mohnot 1977), existence of only the snub-nosed monkey *Rhinopithecus roxellanae* is doubtful. Groves (1970) is skeptical about its occurrence as reported by Gee (1952). Even some 25 years after the report of Gee, no one has ever seen this monkey in nature in this habitat. It is, therefore, essential now to survey forests of Manipur in eastern India to ascertain its status in India.

Among the remaining 17 species, the Madras tree-shrew *Anathana ellioti*, the common tree-shrew *Tupaia glis*, the rhesus monkey *M. mulatta*, the bonnet monkey *M. radiata*, and the hanuman langur *Presbytis entellus*, are quite common in their distribution zone. The Nicobar tree-shrew *T. nicobarica*, the Assamese macaque *M. assamensis*, the long-tailed macaque *M. fascicularis*, the pig-tailed macaque *M. nemestrina*, the capped langur *Presbytis pileatus* and the hoolock gibbon *Hylobates hoolock*, are occasionally seen in the forests of their range, but their population estimates are not known. The slow loris *Loris tardigradus*, the slender loris *Nycticebus coucang*, the stump-tailed macaque *M. arctoides*, the lion-tailed macaque *M. silenus*, the golden langur *P. geei* and the Nilgiri langur, *P. johnii* are some of the species threatened with extinction. The lion-tailed macaque and the golden langur have already been included in the Red Data Book of the IUCN.

Information pertaining to distribution, group structure, population estimates and such other features of all the 18 species found in India is given in Table 1.

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TABLE 1

DISTRIBUTION, GROUP-SIZE, POPULATION STATUS, ETC., OF INDIAN PRIMATES

Common name	Species name	Habitat type and approximate geographical distribution in India	Common group-size	Population status	Current study sites	Source
1	2	3	4	5	6	7
1. Madras Tree Shrew	*Anathana ellioti*	Tropical rain forest and thorny jungles of India, south of the Ganges.	—	Common	—	Blanford, 1888-91.
2. Common Tree Shrew	*Tupaia glis*	Thick rain forest and mountain jungles, oak parkland and evergreen forests upto 1200 m altitude in eastern India including, Sikkim, Manipur, Assam.	Lives alone or in pairs.	Common	—	Blanford, 1888-91 ; Roonwal, 1949.
3. Nicobar Tree Shrew	*Tupaia nicobarica*	Nicobar Islands (Bay of Bengal).	—	Not known	—	Pocock, 1939 ; Napier and Napier, 1967.
4. Slender Loris	*Loris tardigradus*	Tropical rain forest open woodland, swampy coastal forests and evergreen forests of southern India, probably north to the Tapti River.	Usually lives alone or in pairs.	Uncommon	Bangalore	Webb-Peploe, 1947 ; Hutton, 1949.
5. Slow Loris	*Nycticebus coucang*	In densest parts of tropical rain forests of Eastern India.	Single, couple or small family groups of 3.	Uncommon	—	Fooden, 1971 ; Medway, 1969.
6. Stump-tailed Macaque	*Macaca arctoides*	Dense forests, near cultivated land and villages of Assam (eastern India).	25-30 individuals.	Uncommon	—	McCann, 1933c ; Bertrand, 1969 ; Southwick and Siddiqi, 1970.

7.	Assamese Macaque	*Macaca assamensis*	Heavy forests of the Himalayas from Uttar Pradesh through Nepal, Sikkim, and Bhutan to Assam. Also South to Sunderbans.	Large companies.	Not known	—	Pocock, 1939.
8.	Long-tailed Macaque	*Macaca fascicularis*	Coastal areas in Nicobar Island (Bay of Bengal).	5-15 individuals.	Not known	—	Fooden, 1969 ; Blanford, 1888-91.
9.	Rhesus Macaque	*Macaca mulatta*	Lives in wide variety of habitats, cities, villages, farms, forests, mountains, semidesert and mangrove swamps. In whole of Northern India South to River Godavari.	Average group size varies from 11.3 ± 1.4 to 49.8 ± 5.8.	Common	Maroth (Raj.), Aligarh & Dehradun	Southwick *et al.*, 1965, 1975.
10.	Pig-tailed Macaque	*Macaca nemestrina*	Dense evergreen forests of Assam.	No precise information.	Not known	—	McCann, 1933c.
11.	Bonnet Macaque	*Macaca radiata*	In different kinds of forests and areas of cultivation going upto about 2100 m altitude in Peninsular India, north to Bombay and the River Godavari.	7-76 individuals.	Common	Bangalore, Mysore	Simonds, 1965, Rahaman & Parthasarathy, 1967 ; Krishnan, 1972.
12.	Lion-tailed Macaque	*Macaca silenus*	Peninsular India (Western Ghats, principally Kerala) upto 800-1,300 m altitude in the Nilgiri, Anaimalai and Cardamom Hills.	4 to over 30 usually 10-20.	Uncommon	Tirunelveli District	Sugiyama, 1968 ; Kurup, 1975 ; Southwick and Siddiqi, 1970.
13.	Hanuman Langur	*Presbytis entellus*	Variety of habitats in whole of India except the Great Indian desert going up to 4000 m in the Himalayas.	2-120, group size varies from habitat to habitat.	Common	Jodhpur ; Dehradun	Roonwal and Mohnot, 1977.

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13. Hanuman Langur	*Presbytis entellus*	Variety of habitats in whole of India except the Great Indian desert going up to 4000 m in the Himalayas.	2-120, group size varies from habitat to habitat.	Common	Jodhpur ; Dehradun	Roonwal and Mohnot, 1977.

TABLE 1—(*Contd.*)

Common name	Species name	Habitat type and approximate geographical distribution in India	Common group-size	Population status	Current study sites	Source
1	2	3	4	5	6	7
14. Golden Langur	*Presbytis geei*	In dense tropical deciduous forest of North-western Assam to about 2400 m altitude.	4-40 mostly 10-18.	Uncommon	—	Oboussier and Maydell, 1959; Wayre 1968; Gee, 1955.
15. Nilgiri Langur	*Presbytis johnii*	Generally inhabits the sholas in Southern India (Western Ghats south of Coorg; the Nilgiri, Anaimalai, Brahmagiri and Palni Hills). Usually not below 915 m altitude.	3-25	Now rare	Nilgiri Hills.	Poirier, 1970.
16. Capped Langur	*Presbytis pileatus*	Dry tropical deciduous forests and dense evergreen hilly forests of north-eastern India.	8-10 (polygamous in winter) 6-2 (multimale).	Not very Common	—	McCann, 1933b; Khajuria, 1962.
17. Snub-nosed Monkey	*Rhinopithecus roxellanae*	Eastern India (Manipur around 1,520 m altitude and Assam).	100 or more (in China).	Presence doubtful	—	Gee, 1952; Groves, 1970.
18. Hoolock Gibbon	*Hylobates hoolock*	Hill forests of Assam and Nagland.	Family of mated pair and 1 or more young ones. Largest 7.	Not known	—	McCann, 1933*a*.

Indian Species in Institutions Abroad

Much before the virus vaccines became popular as a commercial possibility, the Indian primates especially the rhesus were in demand abroad. The first record of rhesus export to USA is of 1930. During the same time, the Sukhumi Institute of Experimental Pathology and Therapy, USSR, probably started using our monkeys. This Institute was established in 1927. The first colony of rhesus monkeys came into existence at Cayo Santiago Island, Puerto Rico, with 450 monkeys shipped from India in 1938, but the demand of macaques reached the level of about 250,000 in the same year (Carpenter 1972).

By now, several primate colonies have been established namely Parlov, Moscow, Leningrad and Kiev, in USSR ; seven regional primate research centres in USA ; at Rijswijk in Netherlands and also in France and Italy. This is in addition to hundreds of laboratories, institutes, University departments, and pharmaceuticals using Indian primates, especially the rhesus, in USA, U.K. and other countries in Europe (Hobbs and Bleby 1976).

Exploitation of Primates in India

Of about 5,000 monkeys used annually, some 50% are utilized by various medical institutes in the country numbering about 25 in different research activities. The remaining share is : drug research (*c.* 30%) ; vaccine production (*c.* 10%) and reproductive biology research (*c.* 6%). To a small extent (*c.* 4%), the monkeys are used for pharmacology, cytology, genetics, nutrition, tissue culture, ethology and other branches of study. With increasing research facilities the demand for monkeys will mount rapidly.

Export of Rhesus Monkeys and Associated Problems

No precise export data for the thirties are available due to the then impending World War II. But thousands of rhesus must have been shipped during that period as well. The flow of rhesus from India continued during forties and fifties. Nearly 200,000 monkeys had been exported by the late 1950's to United States alone. This number decreased by about 50,000 a year to the entire world in the sixties. Between 1965 and 1974, an average of about 35 to 49 thousand rhesus were sent out every year (Ted Patterson, Pers. Comm. 1975). Details of export for this period is as under :

Year	Total Export	Export to USA
1965	39,263	27,121
1966	42,922	26,268
1967	46,088	30,849
1968	47,865	30,315
1969	49,028	29,734
1970	39,546	26,056
1971	35,271	21,152
1972	39,087	21,330
1973	39,980	25,413
1974	34,158	22,218

Interestingly, the rhesus requirement abroad is 18 times greater as compared to our domestic need. From the year 1975, export has been restricted to 20,000 monkeys per annum. Yet, it is the most frequently used species, which is about 60% of all species combined (Nolan 1975). Thus in the last four decades, the total harvest for work at home and abroad must have touched a record number of over 2 million monkeys—a number that cannot be imagined for any other primate species found elsewhere in the World.

Inhuman Treatment

The sacrifices, and pain borne by rhesus in the hands of scientists throughout the world has not only served the cause of science but of humanity at large. As a mark of tribute, we could assign this animal the statue of an 'International Animal'. But, unfortunately all is not well with this species presently. It is depressing to note that even the agreement for its use in a humane manner, and that too only for medical research and vaccine production, has not been fully honoured. Results of current works indicate that all of them are not always used in medical research or in breeding programmes, but are frequently used for other purposes. For example, of about 20,000 rhesus imported by the United States in 1975, some 83% were killed during the year of their arrival in a variety of projects not relevant to medical research.

The use of rhesus in laboratories appears to have become a fancy. For example, hundreds of them are killed in trauma causing experiments. The important trauma experiments involved are : Blunt chest and abdomen, burns, gunshot wounds, severe shocks and injuries caused by crashes. Experiments on electric shocks, brain damage, aggression, water and food deprivation, drug addiction, heat and cold avoidance and isolation were frequent, taking the life of several hundred of monkeys every year. Equally large numbers are used in narcotic research. In most of these experiments referred above any other mammal could have served the purpose, if such experiments are unavoidable.

Much of the ' research ' is not medical at all. Most of the so called medical work is of no value in solving human diseases—what is the use of such work as dipping rhesus monkeys in boiling water, slamming them in the guts with a cannon impactor or addicting them to narcotics such as heroin, just to see what happens? It is utterly senseless to torture monkeys in these ways.

Rhesus in Chemical-Biological Warfare :

In the recent past, they have been increasingly used in radio-osteonecrosis, X-radiation and radiation killings. The latest in the series is their use in estimating radiation effects of neutron bomb tests. They were formerly used at atomic bomb tests, being tied down at varying distances, from the bombing site, many of these animals later developing cancer.

Some laboratories have used rhesus monkeys to study diseases like, tularemia, poliomyletis, psittacosis, Rift Valley fever, St. Louis encephalitis, equine encephalitis, Japanese B encephalitis, anthrax, brucella suis, coxiella, Simian herpes, histoplasmosis capsulatum and mycobacterium TB. Many of these disease agents, spread through air, are potential weapons in biological warfare, anthrax being one of the most deadly.

Because of these dangers, Mohnot (1975) suggested ban of rhesus export at least for two years, allowing time to ascertain the implications at home and abroad.

Present Rhesus Population :

Although no accurate overall population figures are available except for small pockets, field work by Neville (1968), Lindburg (1971) and Mukherjee and Mukherjee (1972) provides helpful data for approximating rhesus population figures of limited areas. However, Southwick *et al.* (1975) have estimated the rhesus population of Uttar Pradesh (rhesus occurs in Kashmir, Himachal Pradesh, Madhya Pradesh, Bihar, Punjab, Haryana, Rajasthan, Gujarat and parts of Maharashtra, in addition to U.P.) to about 500,000 monkeys, and about 17,600 births per year in the total population with about 60,000 individuals for harvest every year. Whether this situation exists today or not has yet to be verified, and, the most important point at the moment is to survey the whole geographical range of its distribution to assess the overall population status and to infer statistically the number of individuals available for harvest every year. This will also help develop a scientific plan of its conservation and population management for times to come. If necessary breeding colonies can also be established in natural habitats for maintaining supply of healthy, disease-free, quarantined animals of known pedigree to match requirements of indenting agency at home and abroad.

OTHER SPECIES IN USE

In addition to the rhesus, *Loris tardigradus*, *Nycticebus coucang*, *M. radiata* and *P. entellus* have been frequently used in the Indian laboratories for biological and biomedical researches. However, the first two are now used very occasionally owing to their non-availability on account of their presence only in the interior of the forests and shrinking population. *M. radiata* is still common in peninsular India and is used frequently in laboratory studies. *P. entellus*, is the most widespread of the Indian primates and is a very appropriate animal model for reproductive research. It has been used extensively in the recent past in fertility, sterility and hormone research.

The use of the remaining Indian species in laboratories is infrequent.

THREATENED SPECIES

At one time a common laboratory animal, the slender loris *Loris tardigradus*, is found in tropical rain forest, open woodland and swampy coastal forests of South India. Its sluggish nature and demand for its eyes for eye diseases takes a big toll of this species every year, and is now threatened with extinction. The present population of the slow loris *Nycticebus coucang*, is not known to any extent. It is restricted to Assam and is occasionally seen in the local market for sale, being easily tamed and making a good pet. The population has now been threatened due to forest-felling operations in its habitat.

The stump-tailed macaque *M. arctoides*, is said to occur in dense forests upto *c*. 2400 m elevation in Meghalaya and Arunachal Pradesh. Its rarity was discovered in 1965 when a survey carried out by Mireille Bertrand, R. K. Lahiri and George Schaller failed to locate a single group after spending several weeks (Southwick and Siddiqi 1970). Its disappearance from its range was reported earlier by Bertrand (1969). The lion-tailed macaque *M. silenus*, a truly arboreal species, is threatened with extinction. Kurup (1975) reported existence of only 800 macaques organised in 55 groups over an area of about 2800 sq km. Earlier, Sugiyama (1968) gave its population around 1000 individuals and did tell about its possible extinction in the near future. However, its habitat is now expected to be protected by law and all forest-felling operations in its distribution zone of *shola* forests in the Nilgiri hills stopped.

The Nilgiri langur *Presbytis johnii*, a once common species of Nilgiri Hills, is threatened by regular destruction of its habitat, the *shola* forests, because of its exclusive arboreal habits. It is also frequently killed by jungle tribes for food, fur and medicines. A tonic made from monkey parts and herbs and marketed as *karung kurangu rasayanam* (black monkey medicine) is widely used in south India (Poirier 1971). Krishnan (1972) believes that the position of this langur has improved in recent years. Kurup (1975) also states that its former distribution in patches is now becoming contiguous. Yet, the extensive destruction of *sholas* in the recent years for agriculture purposes have jeopardised population. Further, the lion-tailed moneky as well as the Nilgiri langur, being very specific in habitat utilization, particularly the trees, their protection can only be achieved if forests of their range are not only protected but are further provided with plantation of species used by them in nature. This will also avoid congestion and over population in times to come.

The golden langur *P. geei*, of Eastern India, is found only in Goalpara district of Assam and in parts of Bhutan along River Manas upto *c.* 2400 m altitude. This interesting langur lives in dense tropical deciduous forests. From field studies by several workers (Gee 1955; Oboussier and Maydell 1959; Wayre 1968; Khajuria 1962; and Mukherjee and Saha 1974), it is evident that only a limited number exists. All of the observers have encountered only a few groups each organised in 4-40 individuals. The geographical distribution and population status can be studied further, taking advantage of existing information on its ecology.

CONCLUSIONS

From the foregoing account it is amply clear that the future of our several primate species is still bright. Timely action, wise and scientifically planned management and exploitation can certainly avoid the distressing situation that has developed in recent years due mainly to human interference. Extensive destruction of primate habitats through deforestation, urbanisation, and commercial exploitation have curbed population growth of several of our arboreal species. Of these, five species are now endangered.

Till now no serious effort with regard to their conservation, management, planning and research has been made. A blue print is now urgently needed to initiate a phased long range scientific programme to take stock of the present situation and to undertake sound conservation plans needed for sustained yield so that regular harvest of monkeys from nature could be maintained for legitimate requirements. It should be a twenty year plan framed in consultation with competent, both government and non-government.

Abundant species like *T. glis*, *M. radiata* and *P. entellus*, should be cared for, protected and used in biomedical research to ease pressure on the heavily used monkey, the rhesus, which too can be placed among the common species. In the present set-up, rhesus population management is very important. Strict surveillance during commercial harvest is essential at all stages from trapping to shipping, to minimise loss. The local people, villagers and farmers have to be educated to show restrain in handling rhesus, particularly when it raids their fields and orchards. The people can be compensated for loss if necessary to discourage possible poisoning and killing. Monoculture reforestation should be discouraged and export of primate species in the wild should not be allowed except for scientific purpose.

Where information on the ecology and population of a species does not exist, immediate research programmes should be initiated to fill in the existing lacunae so that sound conservation programmes can take shape. For this, research on primates in Universities should be supported with funds and other assistance. Having known the true picture of population status and geographical distribution, investigations on population dynamics and carrying capacity of the habitat can be undertaken.

Where monkeys have established themselves in urban areas, they should be translocated to near-by jungles to avoid nuisance, or else they will be either trapped or killed. With their presence around, transmission of viral, bacterial and other diseases pose a problem. Bonnet groups have been successfully translocated to places outside Bangalore City in the last 3 years. This can also be done with rhesus in several cities, towns and villages in northern India.

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SEASONAL CHANGES IN BODY WEIGHTS OF SOME RODENTS FROM SOUTH INDIA

R. K. Chandrahas[1]

INTRODUCTION

In connection with the studies on the wild rodent hosts and flea vectors involved in the epidemiology of plague in the southern India plague focus, emphasis was laid on the ecology of burrowing wild rodent species. Chandrahas and Krishnaswami [1974 and 1974 (a)] and Chandrahas (1974) reported the findings on the ecology of the Indian gerbil *Tatera indica hardwickei* (Gray), the soft-furred field rat *Rattus m. meltada* (Gray), the brown spiny mouse *Mus p. platythrix* (Bennett) and the little Indian field mouse *Mus b. booduga* (Gray) in Kolar (Karnataka State). In the present communication, the seasonal fluctuations in body weights of these four species of rodents are summarised and presented.

METHODS OF STUDY

The rodents were collected by excavating their burrows at four weekly intervals by utilizing the services of professional rat-catchers. The animals were obtained from the neighbourhood of Kolar town as well as from some localities in Kolar taluk falling in a radius of about 8-9 miles from Kolar town. The rodents collected in the field were transferred to well ventilated tins, sorted species-wise and transported to the laboratory. The animals were sexed and weighed after anaesthetizing with chloroform.

RESULTS AND DISCUSSION

The data recorded on the mean body weights monthwise with standard deviation and range for 812 adult specimens (373 males and 439 females) of the Indian gerbil *Tatera indica hardwickei*; 548 specimens (251 males and 297 females) of *Rattus m. meltada*; 725 specimens (335 males and 390 females) of *Mus p. platythrix* and 1202 specimens (538 males and 664 females) of *Mus b. booduga* is analysed and presented in Tables 1, 2, 3 and 4 respectively.

(a) **Tatera indica hardwickei :**

The mean body weights of adult males of *Tatera indica hardwickei* ranged from 90.0 to 245.0 gm. There was a long span of stabilization of body weights (between 127.51 and 130.05 gm) during May to August preceding the rise and November to January following the peak in October. However, individuals exhibiting higher body weights were encountered in the population in September and October as well as in January when the minimum limit in the range exceeded over 100 gms.

The body weights of *Tatera i. hardwickei* reached the apex in September and the entire period from January through August indicated almost uniform body weights ranging between 108.03 gm and 119.14 gm. The mean body weights ranged from 80.00 gm to 186.70 gm.

In this species, the weight at sexual maturity is considered to be 90.0 gm and above for

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TABLE 1

SEASONALCHANGES IN THE BODY WEIGHTS OF *Tatera indica hardwickei* (GRAY) ADULTS IN KOLAR (KARNATAKA STATE)

Month	Male				Female				t between Male & Female Mean
	Number of animals	Weight in gms			Number of animals	Weight in gms			
		Mean	SD ±	Range		Mean	SD ±	Range	
January ..	23	144.00	36.89	102.5-234.0	26	117.42	21.78	86.00-157.00	3.11*
February ..	33	128.76	25.43	98.0-169.5	43	119.14	23.80	80.80-163.00	1.67*
March ..	18	117.27	28.27	92.0-179.0	22	117.89	20.80	90.40-152.00	0.07
April ..	31	111.50	14.16	94.0-145.5	27	112.09	21.56	82.00-153.80	0.54
May ..	37	129.70	21.77	98.0-171.6	47	111.84	22.14	84.80-156.60	4.01*
June ..	34	130.05	18.91	92.0-178.0	29	110.75	20.73	80.00-162.00	3.92*
July ..	40	127.51	18.35	92.8-161.3	45	108.03	12.25	85.40-138.00	6.24*
August ..	41	127.98	20.87	94.8-165.0	31	114.92	18.07	82.00-148.00	2.93*
September ..	25	154.58	31.25	106.0-207.0	27	137.77	16.68	107.00-163.40	2.39*
October ..	18	167.44	29.82	124.0-245.0	30	126.64	18.75	100.00-175.70	5.73*
November ..	37	143.94	23.72	90.0-190.6	66	122.31	27.06	80.00-168.50	4.03*
December ..	36	143.44	36.53	90.8-210.5	46	130.38	27.92	84.00-186.70	1.82*

* Significant at 5% level.

TABLE 2

SEASONAL CHANGES IN THE BODY WEIGHTS OF *Rattus m. meltada* (GRAY) ADULTS IN KOLAR (KARNATAKA STATE)

Month	Male				Female				t between Male & Female Mean
	Number of animals	Weight in gms			Number of animals	Weight in gms			
		Mean	SD ±	Range		Mean	SD ±	Range	
January ..	26	54.13	13.83	38.0-94.8	31	56.97	13.88	36.0-92.0	0.75
February ..	24	54.30	14.86	37.0-90.6	19	49.95	9.33	35.8-64.6	1.08
March ..	12	53.47	10.65	37.8-68.6	17	46.25	8.05	35.6-61.8	2.00*
April ..	21	43.86	6.49	36.5-57.8	13	44.39	6.72	37.0-58.6	0.22
May ..	20	53.17	8.03	38.5-65.4	21	53.29	8.60	40.2-71.6	0.46
June ..	13	73.88	13.13	57.4-97.6	23	59.92	11.59	42.9-84.0	3.21*
July ..	15	61.62	17.23	39.6-92.5	26	55.57	11.77	36.6-91.8	1.29
August ..	21	51.66	12.62	35.9-75.0	18	52.61	10.98	35.2-75.6	0.24
September ..	23	56.85	11.71	42.0-84.8	23	48.43	8.72	35.0-55.0	2.71*
October ..	20	64.85	13.14	48.8-90.2	20	57.31	8.74	42.5-75.2	2.08
November ..	29	54.93	18.26	36.8-102.3	33	50.30	13.14	35.8-80.0	1.14
December ..	27	59.79	15.56	35.8-93.0	53	55.34	11.28	36.8-70.0	1.44

* Significant at 5% level.

TABLE 3

SEASONAL CHANGES IN THE BODY WEIGHTS OF *Mus p. platythrix* (BENNETT) ADULTS IN KOLAR (KARNATAKA STATE)

Month	Male				Female				t between Male & Female Mean
	Number of animals	Weight in gms			Number of animals	Weight in gms			
		Mean	SD ±	Range		Mean	SD ±	Range	
January ..	19	31.66	5.90	19.9-44.0	27	29.19	4.30	21.6-43.6	2.13*
February ..	17	29.15	6.21	19.8-39.4	26	28.13	6.37	20.0-44.0	0.52
March ..	26	28.76	6.91	20.0-35.0	22	29.55	4.82	20.0-36.4	0.45
April ..	25	22.40	2.26	19.8-27.4	27	23.88	3.12	19.8-30.0	1.91*
May ..	31	21.02	1.65	19.8-24.0	30	21.59	2.00	19.5-25.0	1.18
June ..	32	21.67	3.60	19.0-28.0	34	21.36	1.72	19.5-25.0	0.42
July ..	38	24.36	3.91	19.9-31.5	28	21.66	2.38	19.8-39.8	3.18*
August ..	28	29.89	4.24	22.6-35.0	42	27.25	5.79	20.0-41.2	2.04*
September ..	40	33.02	7.33	22.0-49.6	43	30.84	7.18	20.0-48.4	1.35
October ..	29	33.89	9.48	20.0-48.9	41	36.02	7.98	22.8-53.2	1.00
November ..	35	37.53	6.75	27.0-48.6	44	33.74	8.74	22.0-50.2	2.09*
December ..	15	39.84	7.23	24.8-47.8	26	35.91	7.18	23.6-46.0	1.64

* Significant at 5% level.

TABLE 4

SEASONAL CHANGES IN THE BODY WEIGHTS OF *Mus b. booduga* (GRAY) IN KOLAR (KARNATAKA STATE)

Month	Male				Female				t between Male & Female Mean
	Number of animals	Weight in gms			Number of animals	Weight in gms			
		Mean	SD ±	Range		Mean	SD ±	Range	
January ..	23	10.63	3.13	7.0-15.0	22	9.22	1.34	7.0-12.0	1.91*
February ..	32	9.20	2.02	7.0-12.5	37	9.25	2.08	7.0-14.0	0.02
March ..	29	7.91	1.01	6.8-10.0	33	8.24	1.25	6.5-11.0	1.30
April ..	45	7.09	0.89	6.0-10.0	54	6.66	0.86	6.0-10.0	2.46*
May ..	46	7.94	1.04	6.5-10.0	50	7.62	0.74	6.4-10.6	1.69
June ..	45	8.10	1.28	6.5-12.0	70	7.31	0.88	6.0-10.0	3.92*
July ..	64	8.26	1.30	6.8-11.5	64	7.65	0.87	6.5-10.0	3.10*
August ..	63	8.89	1.59	7.0-12.0	67	8.53	1.32	7.0-11.0	14.38
September ..	53	11.20	2.03	7.0-15.0	66	9.12	1.53	7.0-12.0	6.36
October ..	71	11.52	2.76	7.0-17.0	108	11.40	2.53	7.0-20.0	0.31
November ..	33	11.68	2.26	7.0-14.5	47	11.18	2.27	8.0-15.5	1.35
December ..	34	10.75	2.56	7.0-14.8	46	10.66	2.12	7.0-14.0	0.15

* Significant at 5% level.

males and 80.0 gm and above for females. The breeding season extended from August to April with a peak in the reproductive performance during October and November. Considering the combined data for both the years it was observed that 50 per cent of the females collected in October were pregnant and 43.0 per cent lactating during November (Chandrahas & Krishnaswami 1974). In view of this, it is likely that there was a pick up in the body weights in females from September to December.

(b) **Rattus m. meltada :**

The body weight ranged from 35.8 gm to 102.3 gm. The body weights in males started ascending from May and reached the peak in June (73.88 gm) and declined thereafter. There was a minor peak in October (64.85 gm). The period between November and March was almost plateaued when the body weights fluctuated from 53.47 gm to 59.79 gm.

Projection of two peaks ; one major (59.92 gm) in June and the other minor (57.31 gm) in October was observed in females of *Rattus m. meltada.* The body weights diminished in April (44.39 gm) and the mean body weights for the entire period ranged from 35.0 gm to 92.0 gm.

In *Rattus m. meltada* the weight at sexual maturity is considered to be 35.0 gm and above for both males and females. Although this species has been found to breed throughout the year, peak reproductive performance was noticed during the months October to January when the percentage of pregnant animals ranged from 22.4 to 55.5 per cent and the lactating females from 19.3 to 36.3 per cent. There was a spurt in the reproductive activity in May when the population sampled constituted 38.0 per cent pregnant and 43.0 per cent lactating specimens (Chandrahas and Krishnaswami 1974 a).

(c) **Mus p. platythrix :**

The mean body weights in males decreased in May, June and July and attained maximum in October (36.02 gm). During November-December and January-March the body weights were remarkably stable. The range was from 19.5 gm to 53.2 gm.

The mean body weight of *Mus p. platythrix* males ranged from 19.0 gm to 49.6 gm. Decline in the body weight was recorded in April, May and June and the minimum was touched in May. There was a gradual rise in body weights from September onwards extending upto January with a peak in December.

The weight at sexual maturity is 20 gm for both the sexes. Breeding extends from January-March and August-December, with a peak in reproductive activity in November, when 38.6 per cent and 48.0 per cent specimens exhibited pregnancy and lactation, respectively.

Mus b. booduga was the lightest. The mean body weights of males ranged from 6.0 gm to 17.0 gm. Depression in body weights was observed in March, April and May and reached higher level during September to November.

Mus b. booduga females exhibited higher body weights during the period October-December and the mean body weights ranged from 6.66 gm in April to 11.40 gm in October.

The weight at sexual maturity in *Mus b. booduga* is 7.0 gm for both males and females. The breeding season extends from July to March recording a higher incidence during the period September to February. There was a peak in the reproductive activity during October and November (Chandrahas 1974).

From the data analysed in Tables 1, 2, 3 and 4, it is evident that the body weights diminished during the hotter months of the year and increased during September-January period indirectly suggesting that the climatic factors exert influence and have a bearing on the seasonal fluctuations in the body weights. In general, the October-December period found individuals of high mean body weight. Apart from the favourable climatic factors encountered during this part of the year and the availability of sufficient food in the field it could be expected that the higher intensity of breeding constituting good proportion of pregnant and lactating specimens would also contribute to the increase of body weights. It is also possible that there will be a recruitment of individuals just attained maturity into the population from January onwards. April and May are the hotter months in the area studied. The rainy season extends from June to October although a few pre-monsoon showers are experienced before June. The ploughing operations and sowing of seeds are completed by the middle of July and the major crops harvested in December and January.

The rodents would obtain scattered seeds and grains in the field till March and thereafter the rodents are obliged to depend upon various other items like roots, grass etc., due to the paucity of common crops. Hence, the reduction in body weights during the hotter period of the year could largely be attributed to the prevailing climatic conditions and scarcity of food. It is only after the onset of pre-monsoon showers that the green vegetation starts appearing.

There is little information on the fluctuation in the body weights of wild rodents of the Indian sub-continent based on systematic studies. Reporting the findings on the reproductive pattern in male and female Indian gerbil *Tatera indica cuvieri* (Waterhouse) in Bangalore, it was observed that the males lose body weight during May and June, and females from April to August (Prasad 1956, 1961). Also in the Indian gerbil *Tatera indica indica* (Hardwicke) from Bikaner (Rajasthan) a steep peak was observed in June (Jain 1970). Further it is also reported that the mean body weights in the desert gerbil *Meriones hurrianae* (Jerdon) declined after winter touching its minimum in summer in Rajasthan (Prakash 1970).

In general, the males attained a higher body weight than the females in all the four species. The maximum body weight recorded during the present study was 245.0 gm, 102.3 gm, 49.6 gm and 17.0 gm, for males and 186.7 gm, 92.0 gm, 50.2 gm and 20.0 gm for females of *Tatera i. hardwickei*, *Rattus m. meltada*, *Mus p. platythrix* and *Mus b. booduga*, respectively.

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ECOLOGY OF THE BONNET MACAQUE (*MACACA RADIATA* GEOFFROY) WITH SPECIAL REFERENCE TO FEEDING HABITS

George P. Kuruvilla

INTRODUCTION

The food and feeding habits of the Bonnet Macaque *Macaca radiata* in its natural habitat was studied in detail from October 1974 to September 1975. Daily feeding activities, monthly variations in food, phenological data and correlation between the fruiting season and food preference of the macaques were studied. Age and size classes were recognized. All data were collected and recorded by systematic time samplings.

The study was conducted in the forests of Elephanta Island (18° 57′N and 73°E) one of the small islands in Bombay harbour lying 11.27 km from Trombay (Salsette Island). The eastern shore of the Island is approximately 2.4 km from Nava, another small island close to the mainland. The area of Elephanta Island varies from 6.4 to 9.7 sq km depending on the state of the tide. The highest peak on the island has an elevation of 173.2 m. A massive hill runs from north-west to the north-east. However, a valley runs almost through the middle giving an appearance of two separate hills. The major part of the island is covered by forest and the rest by cultivation or wasteland.

Climate : Three seasons can be distinguished—Winter (November to early March), warm during the day and cool at night; Summer (March to May), hot and dry; Monsoon (June to October), humid and wet. The hottest month at Elephanta is May. The cooler months are December to February. Elephanta gets most of its rain from the south-west monsoon. Rainfall is normally heavy during June, July and tapers off during September. The average precipitation for 15 years for this region is 2148.9 mm ranging from 957.8 mm to 3526 mm.

Vegetation : About 70 per cent of the total area is covered with forest and the rest is occupied by rocks and open grasslands. Steep rock precipices are seen on the eastern ridge which also has the best forest. Mangrove occurs along the coast.

Seasonal availability of fruits plays an important role in the ecology of those animal species which feed on them. A study of the abundance and seasonal fluctuation of the plant life was therefore undertaken. There is practically no spot in the study area, which has not been subjected to very drastic degradation through constant cutting of woody vegetation, overgrazing on the herbaceous plants, and summer fires which have all combined to turn the area into a degraded deciduous forest. With the advent of the monsoon, however, the ground becomes covered with dense herbaceous vegetation and the cultivated fields soon turn a brilliant green with paddy *Oryza sativa*.

The vegetational cover of the whole study area was recorded by walking along different trails and noting the species upto a distance of 10-15 m on either side of the trail. Trees with flowers and fruits were recorded separately. This was done once every week and twelve months phenology data was thus collected.

One hundred and seventy-one plant species were identified in sixty-two families. Out of the 171 species of plants identified from the Island, the macaques utilised 36 species. Among the 171 species of plants, 28 species are exotics.

METHODS OF STUDY

The aim of the study was to obtain data on the food habits, habitat utilization, home range, activity pattern, population structure and behaviour of the Bonnet Macaque under natural conditions. All data were collected by direct observation using 8 × 30 binoculars. Special importance was given to feeding behaviour. The observations were made with as little disturbance to the animals as possible. The main study troop named the 'Forest Troop' was less accustomed to people and the animals would begin to move away if approached closer than 30 m. The troop was gradually accustomed to the presence of the observer and in course of time observations were made from very close range (5m and less). 1337.47 hrs. of observations were made on four classes of animals: adult male, adult-female, sub-adult (large juvenile) and juveniles.

Two troops of bonnet macaques occur in Elephanta Island. The troops were named the 'Forest Troop' and the 'Caves Troop' in accordance with their habitat. Data were collected mainly on the 'Forest Troop' which was completely dependent on natural food. The 'Caves Troop' lived largely off the food brought by tourists, during the tourist season. Occasional observations were made on this troop also.

The 'Forest Troop' was continually observed from sun-up to sun-down except for an occasional short break in the morning and afternoon. The troop was usually followed on foot and the behaviour directly recorded. The number of individuals in each of the troops was determined by keeping a count of the animals during various months. Counts were made when the animals crossed a forest road or similar open areas. Group composition was recorded after closely observing each individual. Home range was determined by continuous observation on the troop during this study. The daily travelling distance of the animals was calculated by discreetly following the macaques during their wanderings. The distance they travelled from the roost in the morning, along the route travelled during the day, and back to the roost in the late evening was measured.

RESULTS

THE STUDY TROOP

Population: The 'Forest Troop' of macaques was wild and shy, and was often spread over an area of 100-200 m in diameter. Some of them were missed during counts, quite possibly sub-adult and adult males. Four censuses were made in different seasons of the year: October to December 1974; January to March, 1975; April to June 1975 and July to September, 1975. The 1974 census showed a total of eighty-three animals of all age classes in the two troops. In the second census period it was 95, twelve new born macaques were recorded during this period. During the third census, the total number of animals was 93. The fourth census gave a total of 92 macaques, 'Forest Troop' 43 and 'Caves Troop' 49 (Table 1).

Group sizes and composition varied from time to time, mainly due to births and deaths. Sixteen new-born infants were observed and recorded during this study from both troops, The classes of animals were separated roughly on the basis of size.

Copulation frequency was seen at its maximum during October to November, and the birth rate was at its highest during February and March. Two births were observed in 'Caves Troop' during October and December.

TABLE 1

GROUP COMPOSITION AND CENSUS OF BONNETS ON ELEPHANTA ISLAND, BOMBAY, 1974-75

Census period	Forest Troop						Census period	Caves Troop					
	Ad. male	Ad. female	Sub-adult	Juvenile	Infant	Total		Ad. male	Ad. female	Sub-adult	Juvenile	Infant	Total
Oct. to Dec. 1974 ..	9	13	8	6	2	38	Oct. to Dec. 1974 ..	10	15	7	10	3	45
Jan. to Mar. 1975 ..	10	13	7	6	7	43	Jan. to Mar. 1975 ..	12	15	5	10	10	52
Apr. to June 1975 ..	11	14	4	7	8	44	Apr. to June 1975 ..	12	16	4	7	10	49
July to Sept. 1975 ..	10	16	3	6	8	43	July to Sept. 1975 ..	10	16	7	6	10	49

NUMBER OF NEW-BORN BABIES SEEN DURING THE STUDY PERIOD FROM OCTOBER 1974—SEPTEMBER 1975

		Forest Troop	Caves Troop
October 1974	..	—	1
December	..	—	1
February 1975	..	4	3
March	..	1	4
April	..	2	—

From the ‘ Forest Troop ’ one old male died on 25th July, 1975, perhaps due to old age. A two-day old infant also died from the same troop on 27th April 1975. The mother carried the dead body for two days. Two deaths were noted from the ‘ Caves Troop ’ during the study period. Two juveniles from the ‘ Caves Troop ’ were taken away by tourists during the month of May 1975.

Home Range : The ‘ Forest Troop ’ occupied the eastern and the ‘ Caves Troop ’ the western parts of the Island. The area was constantly used by troop members and was defended from the other troop. The peripheral area was used uncommonly and it overlapped with the territory of the other troop. The home range of the forest troop formed the intensive study area. The home range is comparatively small at Elephanta, a total area of 4.8 sq km being occupied by the two troops. The home range of bonnet macaques is recorded as very large by Rahaman and Parthasarathy (1967), Nolte (1955) and Simonds (1965) in different places in southern India. The troops do not leave their well marked home range and no seasonal change in home range was observed during this study.

Daily Movement : The macaques usually began to move at the first light of the morning (between 0600 hrs to 0630 hrs). The time varied from month to month. The average distance travelled by the troop during a day was about 1.5 to 2 km. The shortest was about one km during rainy season and longest about 2.5 km during favourable conditions. The mean daily movement distance of bonnet troop has been recorded as 790 m by Sugiyama (1971). Average daily movement distance of common langur varies from one to two miles a day (Jay 1965). The variation in distance of daily movement seems to depend on the distribution, volume of food, safety factors and distribution of food trees.

Roosting : The troop roosted in several selected tall trees with dense foliage such as *Tamarindus indica*, *Derris glabra*, *Ficus bengalensis*, *Ficus religiosa* and *Sterculia urens*. They select the highest and safest branches for roosting. The ‘ Forest Troop ’ roosted chiefly in areas within the home range. Occasionally the macaques roost in other places also. In August, October, November and March the animals occupied site 1 : December and April in site 2 and January, February, May, June, July and September in site 3. Tall trees and evergreen creepers were abundant in all roosting sites. Changing of roosts may be due to the following factors : (1) Abundance of food : If the food was abundant near the roost the animals can spend more time in feeding in the early morning as well as late in the evening. (2) Seasonal : During dry seasons most of the trees shed their leaves. At this time the macaques select roosts where evergreen trees are numerous. During monsoon months trees covered by creepers and climbers which offer shelter from the heavy rains were preferred. (3) Safety: There are no predators on the island, yet all the three sites were situated in the least disturbed areas.

Roosting behaviour : The animals leave the feeding grounds for the roost by about sunset. On reaching the roosting site the macaques split into small parties. The animals do not divide into families or sub-groups. Southwick, Beg and Siddiqi (1965) recorded that the rhesus macaques split into families or into sub-groups for roosting. The troops spread on two to three near-by trees for sleeping. Some adult males and the dominant males often preferred to sleep alone. However, more often two or more monkeys hug each other and sleep in such associations. More than ninety per cent of the troops slept clasping each other (Koyama 1973). The monkeys climb to the top of the trees and then select strong branches and gather in small groups and sleep. The tendency to sleep clasped together is more among females and infants, but is negligible between females and males (Koyama 1973). The lion-tailed macaques *M. silenus* prefers extreme branches of very tall trees. Trees near the feeding place were often used as roost by the bonnets. All troop members, both male and female, select places for sleeping. During rains more individuals sleep or rest clasped together. The dominant male sits on a top branch to sleep as well as to keep watch. Usually the dominant male would be the last to sleep. Mothers with infants often embrace another to sandwich the baby in between them and prevent it from falling at night. Once they settle down for the night's rest the animals remain in the same position till dawn. There is no perceptible activity after dark.

Food and Feeding Habits

The food habits of bonnet macaques have not yet been studied in depth. General food and feeding methods of bonnets occupying a garden sector of Bangalore have been mentioned by Rahaman and Parthasarathy (1969). Food material includes leaves, flowers, fruits, seeds and insects such as grasshoppers, certain flies and pupae.

The data were collected by systematic sampling of food habits of the 'Forest Troop' mainly but occasional observations were made on the 'Caves Troop' also. Systematic time sampling during a month consists of data collection during three to five consecutive days of observation, from dawn to dusk, or from early morning till noon, or afternoon to late in the evening at an interval of one to two days. The first sustained activity by a monkey during a sampling period was recorded. Then the activity of several members, according to the age classes (adult male, adult female, sub-adult and juvenile) were noted during each period. The classification of the animals into age classes was in the manner of Jay's (1965) classification of common langurs.

Usually observations were possible at a close range when the animals fed together. Although, the same animal could not be studied every day without marking, the observations on particular age groups were recorded separately. The total feeding time is deduced from the total observation time for each day. The following data were recorded :

(*a*) Daily feeding rhythm and time spent on feeding in each hour of the day.

(*b*) Monthly variations in feeding time.

(*c*) Time spent in feeding on each food item.

(*d*) Preference of food items.

Most of the plant items were identified. Identification of animal material was extremely difficult and almost impossible in many cases. Animal food items like grasshoppers, lizards, and some pupae could be identified without much difficulty and were recorded. Insects which were taken by the animals in most cases remained unidentified. The unidentified insects were listed as 'insects'.

The bonnet macaque is omnivorous and feeds upon a variety of leaves, flowers, fruits, seeds, grass-blades, grass flowers and animal material. The animal material included a variety of insects such as caterpillars, grasshoppers, and flies. Lizards were also eaten. The macaques preferred plant to animal material. This related to the abundant plant food items available. Water is taken in by direct licking from holes on tree trunks or on rocks or from a well platform (near villages) without using hands. At times the animals put their hands into the water holes and licked the droplets from their arm and fingers.

Plant food of macaques : The important fact about bonnet diet is in the selection of variety of food materials. Thirty-six species of plant food were found to be eaten. The plants eaten and parts consumed in each plant by the macaques are shown in Table 2.

The bonnets move early in the morning from the roost to their daily routine of feeding with some kind of warming up or morning play, especially among the sub-adults and the juveniles. At times the mature animals also showed an inclination for such kind of activities in the morning. The macaques were seen sunning before commencing to feed. The period of sunning varies according to the seasons being longer during cold and rainy seasons.

The feeding rhythm showed two peaks during the day ; between 0800 hrs to 0900 hrs and 1500 hrs to 1600 hrs from October to April. During the month of May there was only one peak, between 1500 hrs to 1700 hrs. In this month they spent more time under shade during the day, probably because of the high day temperature. The feeding behaviour was more or less similar in June also. The reason for this is not clear. During the month of July the animals did not show preference for any particular feeding period and fed throughout the day. This may be due to the continuous cloud

TABLE 2

PLANT FOOD ITEMS UTILIZED BY BONNET MACAQUES

Species	Part consumed
GRASS	
Setaria glauca Beauv.	Leaf and flower
Oryza sativa Linn.	Seed
HERBS	
Urena sinuata Linn.	Fruit
Impatiens balsamina Linn.	Fruit
Crotalaria filipes Benth.	Seed
Cassia tora Linn.	Seed
Solanum indicum Linn.	Fruit
Celosia argentea Linn.	Flower
Colacasia esculenta (Linn.) Schott	Pith of the stem
CLIMBER	
Canavalia virosa (Roxb.) Wight & Arn.	Flower
Dioscorea bulbifera Linn.	Fruit
SHRUB	
Lantana camara Linn.	Flower and fruit
Carissa carandas Linn.	Fruit
TREES	
Anona squamosa Linn.	Flower and fruit
Flacourtia ramantchi L'Herit	Fruit
Salmalia malabarica (DC.) Schott & Endl.	Flower
Cansjera rheedii Gmel.	Fruit
Zizyphus mauritiana Lamk.	Fruit
Scutia myrtina Kurz	Fruit
Erythrina variegata Linn.	Seed
Dalbergia latifola Roxb.	Leaf
Pterocarpus marsupium Roxb.	Fruit
Derris glabra Vent	Seed
Tamarindus indica Linn.	Seed
Acacia farnesiana Willd.	Seed
Alangium salviifolium (Linn.f.) Wang	Fruit
Morinda coreia Buch.-Ham.	Fruit
Manilkara hexandra (Roxb.) Dubard	Fruit
Diospyros montana Roxb.	Fruit
Heterophragma quadriloculare (Roxb.)	Seed
Bridelia squamosa Gehrm	Fruit
Sauropus quadrangularis Muell	Fruit
Holoptelea integrifolia Planch.	Fruit
Streblus asper Lour.	Fruit
Ficus bengalensis Linn.	Fruit
Ficus religiosa Linn.	Fruit

cover. The animals did not feed intensely at any one time during the rains. In the months of August and September the feeding peak appeared to be similar to that of October to April.

The monthly feeding time variations showed that from October to May and September the adult females spend more time in feeding than the other animals. One of the possible reasons for this may be pregnancy and parturition (from mating to 2 months after the delivery of the off-spring). Observations regarding adult females were restricted to those which were breeding. The adult males spend more time for feeding than the sub-adult and juveniles. From June to August the adult females spend less time in feeding than other animals. The monsoon starts in June and heavy rains continue upto the end of August. So the adult females with the babies spend more time protecting the young ones from the heavy rains. This may be one of the reasons for the sudden fall of feeding time for adult females from June to August. Others also spend less time during these months than in other months. Fruits were most abundant in the months of October, December, January, March and April. The macaques spend more time for feeding during the above months except October. During the month of October the major food was paddy but the time spent in collecting this food is less, probably because (*a*) the paddy fields were outside their regular feeding range and (*b*) the animals had to wait for a chance to feed without disturbance from guards. Paddy was available only during the month of October.

The food taken each month of the year is given below. The percentage of feeding time is given for new addition each month.

October

	% of feeding time
Oryza sativa	.. 56 to 66.8
Pterocarpus marsupium	.. 9.3 to 15.8
Cassia tora	.. 0.3 to 1.7
Crotalaria filipes	.. 1.2 to 5.8
Derris glabra	.. 0.3 to 1
Dioscorea bulbifera	.. 0.7 to 1

November

Bridelia squamosa	.. 21.5 to 44.3
Canavalia virosa	.. 0.3 to 0.9
Ficus bengalensis	.. 1.1 to 2.6
Lantana camara	.. 11.9 to 18.5
Sauropus quadrangularis	.. 5.5 to 19.6
Solanum indicum	.. 0.2 to 1.4
Urena sinuata	.. 2.3 to 18.6
Crotalaria filipes	.. 1.1 to 3.1
Tamarindus indica	.. 2.6 to 3.3

December

The preferred food for all classes during this month was the fruit of *Bridelia squamosa*. They spent the maximum time on this fruit. Also the sub-adults and juveniles showed more preference for *Bridelia squamosa* than adult males and females. Adult females, sub-adults and juevniles gave next preference to the fruit of *Sauropus quadrangularis* whereas adult males which spent more time on the ground preferred *Urena sinuata*, a small herb. All the above mentioned food items were abundant during December.

Leaves of *Dalbergia latifolia*, flower of *Canavalia virosa*, fruits of *Dioscorea bulbifera*, *Ficus bengalensis*, *Lantana camara*, *Solanum indicum* and seeds of *Crotalaria filipes*, *Derris glabra*, *Heterophragma quadriloculare* and *Tamarindus indica* were the other favourite plant food items.

Dalbergia latifolia	0.3 to 0.5%
Heterophragma quadriloculare	0.2 to 0.3%

January

All classes except juveniles showed a particular preference for the seeds of *Derris glabra* during the month. Juveniles preferred the fruits of *Bridelia squamosa* and *Lantana camara*. Adult females showed equal preference for the fruits of *Derris glabra* and *Lantana camara*.

The three major fruits available during this month were *Bridelia squamosa*, *Derris glabra* and *Lantana camara*. The macaques also ate the fruits of *Ficus bengalensis*.

Flowers of *Canavalia virosa*, fruits of *Sauropus quadrangularis* and *C. filipes* were the other favourite plant food items of the macaques in January.

Zizyphus mauritiana (Lamk.) 5.7 to 9.1%

February

The seeds of *Derris glabra* continued to be preferred during this month also. The adult females fed more on cotyledons of *Derris glabra* than others. This was the dominant food during the month. The seeds of *Derris glabra* occurred abundantly. The macaques showed almost equal preference for the fruits of *Ficus religiosa*, *Lantana camara* and *Zizyphus mauritiana*.

Other favourite plant food items were the leaf blades of *Setaria glauca* ; flowers of *Salmalia malabarica* ; fruits of *Acacia farnesiana*, *Bridelia squamosa*, *Diospyros montana*, *Ficus bengalensis*, *Holoptelea integrifolia*, *Urena sinuata* and *Heterophragma quadriloculare*.

Acacia farnesiana Willd.	1.1 to 1.6%
Setaria glauca Beavn.	1.2 to 2.3%
Diospyros montana	0.5 to 1.4%
Ficus religiosa Linn.	12.3 to 18.9%
Holoptelea integrifolia Planch.	1.8 to 3.7%
Salmalia malabarica (DC.) Schott & Endl.	0.2 to 0.4%

March

Adult males and females preferred the seeds of *Derris glabra* during this month. Sub-adults and juveniles preferred the fruit of *Manilkara hexandra*.

Other favourite plant food in March were the leaf blades of *Setaria glauca*; flower of *Salmalia malabarica* and fruits of *Carissa carandas*, *Flacourtia ramantchi*, *Holoptelea integrifolia*, *Lantana camara*, *Sterblus asper*, *Urena sinuata* and *Zizyphus mauritiana*.

Manilkara hexandra (Roxb.)	22.1 to 29.2%
Carissa carandas Linn.	1.4 to 7.1%
Flacourtia ramantchi L'Herit	10.3 to 16.2%
Streblus asper Lour.	9.4 to 18.1%

April

The macaques showed particular preference for the fruit of *Manilkara hexandra* which was abundant during the month. In addition all four size classes showed more or less equal preference for the fruits of *Flacourtia ramantchi* and *Scutia myrtina*. Flowers of *Anona squamosa*, *Alangium salviifolium*, *Carissa carandas*, *Ficus religiosa*, *Lantana camara*, *Streblus asper* and seeds of *Derris glabra* and *Erythrina variegata* were the other favourite food items during this month.

Scutia myrtina Kurz	15.3 to 16.5%
Anona squamosa Linn.	8.9 to 11.7%
Alangium salviifolium (Linn. f.)	8.1 to 11.1%
Erythrina variegata Linn.	0.2 to 0.7%

May

The bonnets showed very high preference for the fruit of *Alangium salviifolium* during this month. Adult males, females and juveniles spent more time than sub-adults on this food item. The data showed that the preferred food were limited to a few species only during this month compared to all other months except October. May was the hottest month of the year covered by the study. The fruit of *Alangium salviifolium* is soft, fleshy and about 1.15 cm in diameter and weighs about 1.3 gm. The soft and fleshy epicarp may be the reason for the preference of this fruit during May. The water sources were meagre during this month. The only water source for the monkeys was the village well where they rarely got a chance to drink due to the continuous use of the well by the villagers.

Fruits of *Anona squamosa*, *Carissa carandas*, *Lantana camara*, *Manilkara hexandra* and *Scutia myrtina* were the other favourite plant food items of the macaques during May.

June

As in May the macaques showed preference for the fruit of *Alangium salviifolium* during this month. In this month adult males spent more time feeding on this fruit than all other age classes. Second major food item of the macaques during June was *Lantana camara*. In this case juveniles spent more time feeding on this fruit than all other age classes.

Other favourite plant food items were leaf of *Setaria glauca*, pith of *Colacasia esculenta* and fruits of *Anona squamosa*, *Cansjera rheedii*, *Ficus bengalensis*, *Ficus religiosa*, *Morinda coreia* and *Scutia myrtina*.

After the commencement of the monsoon many herbaceous plants sprout. Among these the macaques showed preference for *Celosia argentea*, *Colocasia esculenta* and different kinds of grasses.

Cansjera rheedii Gmel.	0.3 to 2.7%
Colacasia esculenta (Linn.) Schott.	0.3 to 0.4%
Morinda coreia Buch.—Ham.	7 to 9.2%

July

During this month all age classes except juveniles showed preference for the fruit of *Morinda coreia*. The juveniles showed high preference for the fruit of *Lantana camara*.

Pith of *Colacasia esculenta* ; flower of *Celosia argentea*, *Setaria glauca* and fruits of *Anona squamosa*, *Cansjera rheedii*, *Ficus bengalensis*, *Ficus religiosa* and *Scutia myrtina* were the other favourite plant food items of the macaques.

Celosia argentea Linn.	0.9 to 2.4%

August

All age classes showed preference for the fruit of *Lantana camara* during the month of August. *Lantana camara* was abundant just after the beginning of the monsoon. The juveniles spent more time on *Lantana camara* than all other age classes. The macaques also took *Anona squamosa*, *Impatiens balsamina* and *Cansjera rheedii*, even though these fruits were not in abundance during this month, indicating the need for variety of food materials according to their availability.

Pith of *Colocasia esculenta* ; flower of *Celosia argentea*, *Setaria glauca* and fruit of *Morinda coreia* were the other favourite plant food items during this month.

Impatiens balsamina Linn.	11 to 16.2%

September

Adult females preferred the seeds of *Derris glabra*, whereas the adult males, sub-adults and juveniles showed high preference for the fruit of *Lantana camara*. This is more or less similar to the food habits of the previous month.

Pith of *Colocasia esculenta* ; flower of *Setaria glauca*, *Celosia argentea* and fruit of *Anona squamosa*, *Cansjera rheedii* and *Impatiens balsamina* were the other favourite plant food items of the macaques during September.

Correlation between fruit preference and fruiting seasons :

Seasonal changes in the diet of the macaques were mainly due to the difference in the fruiting seasons of the plants. But this may not the only reason as certain food items were more preferred than others. *Derris glabra* was in fruit from October to April. Adult males and adult females showed preference for the seeds of *D. glabra* throughout its fruiting seasons. Sub-adults fed on the seeds of the same fruit from November to April and juveniles from December to April. *Bridelia squamosa* was in fruit from November to February. All the animals showed more preference for the fruit during the months of November and December and less during January and February. At the same time the sub-adults and juveniles showed preference for the fruit of *Sauropus quadrangularis* during the month of December. Even though *Derris glabra* was in fruit the animals showed preference for the fruit of *Manilkara hexandra* during the month of April. *Manilkara hexandra* was in plenty during this month and in May and June the fruit of *Alangium salviifolium*. *Lantana camara* was abundant just after beginning of monsoon from July to September. The data showed that all the animals spent more time in feeding on the fruit of *Lantana camara*. The animals also preferred the fruit of *Morinda coreia* during July. It was also abundant at that time. (Table 3).

TABLE 3

FRUITING SEASONS OF THE FOOD PLANTS OF BONNET MACAQUE

Species	J	F	M	A	M	J	J	A	S	O	N	D
Anona squamosa	—	—	—	×	×	×	×	×	×	×	×	—
Flacourtia ramantchi	×	×	×	×	—	—	—	—	—	—	—	×
Urena sinuata	×	×	×	×	—	—	—	—	—	×	×	×
Salmalia malabarica	—	—	×	×	×	—	—	—	—	—	—	—
Impatiens balsamina	—	—	—	—	—	—	—	×	×	×	×	—
Cansjera rheedii	×	—	—	—	—	×	×	×	×	×	×	×
Zizyphus mauritiana	×	×	×	—	—	—	—	—	—	×	×	×
Scutia myrtina	—	—	×	×	×	×	×	—	—	—	—	—
Crotalaria filipes	×	×	—	—	—	—	—	—	×	×	×	×
Erythrina variegata	—	—	×	×	×	×	—	—	—	—	—	—
Canavalia virosa	×	×	×	×	×	—	—	—	—	—	—	×
Dalbergia latifolia	—	—	—	—	—	—	—	—	—	×	×	×
Pterocarpus marsupium	×	×	×	—	—	—	—	—	×	×	×	×
Derris glabra	×	×	×	×	—	—	×	×	×	×	×	×
Cassia tora	—	—	—	—	—	—	—	—	×	×	×	×
Tamarindus indica	×	—	—	—	—	—	×	×	×	×	×	×
Acacia farnesiana	×	×	×	×	—	—	—	—	—	×	×	×
Alangium salviifolium	—	—	×	×	×	×	—	—	—	—	—	—
Morinda coreia	—	—	—	—	×	×	×	×	—	—	—	—
Manilkara hexandra	×	×	×	×	×	—	—	—	—	—	—	—
Diospyros montana	×	×	—	—	×	×	×	×	×	×	×	×
Carissa carandas	—	×	×	×	×	—	—	—	—	—	—	—
Solanum indicum	×	×	—	—	—	—	—	—	×	×	×	×
Heterophragma quadriloculare	×	—	—	—	—	—	×	×	×	×	×	×
Lantana camara	×	×	×	×	×	×	×	×	×	×	×	×
Celosia argentea	—	—	—	—	—	—	—	—	×	×	×	×
Bridelia squamosa	×	×	—	—	—	—	—	—	—	×	×	×
Sauropus quadrangularis	×	—	—	—	—	—	—	—	—	×	×	×
Holoptelea integrifolia	×	×	×	—	—	—	—	—	—	—	—	—
Streblus asper	×	×	×	×	—	—	—	—	—	—	—	×
Ficus bengalensis	×	×	—	—	×	×	×	×	×	×	×	×
Ficus religiosa	—	×	×	×	×	×	×	—	—	—	—	—
Dioscorea bulbifera	—	—	—	—	—	—	—	—	×	×	×	—
Colacasia esculenta	—	—	—	—	—	×	×	×	×	—	—	—
Setaria glauca	×	×	—	—	—	×	×	×	×	×	×	×
Oryza sativa	—	—	—	—	—	—	—	—	—	×	—	—

Possible reasons for food preference

Analysis of the data suggests that the preference for food may be an outcome of factors like the nature of the fruit (hardness and softness), colour, taste and position of the fruit on the plants.

From the collected data it seems that the sub-adults and juveniles preferred fruits like *Bridelia squamosa*, *Sauropus quadrangularis*, *Ficus bengalensis*, *Ficus religiosa*, *Lantana camara*, *Zizyphus mauritiana*, *Alangium salviifolium*, *Urena sinuata* and *Manilkara hexandra* than other fruits. These fruits are small in size and the epicarp is also soft and easy to open. *Derris glabra* was seen almost throughout the year, but the epicarp of the fruit is hard. The sub-adults and juveniles showed less preference to this fruit throughout the season. The data show that the hardness of the fruits does not affect the feeding preference in the case of adult males and females.

To a certain extent the macaques were attracted by the colour of the fruit or flower. It was observed that most of the fruits had attractive colour like red, black, orange, yellowish and shades of green, when ripe. The fruit of *Ficus bengalensis* is red and this was a seasonal attraction (November, December, January, February, June and July). This fruit also attracted a number of birds like koel, coppersmith, crows, and bulbuls. Other fruits such as *Sauropus quadrangularis*, *Bridelia squamosa*, *Zizyphus mauritiana*, *Diospyros montana*, *Manilkara hexandra*, *Streblus asper* and *F. ramantchi* also had attractive colours.

The position of fruit on the plant plays a role in selection of the fruit to some extent. In some trees the fruits occur towards the extremity of small branches. In such cases the bigger animals (adult males and adult females) cannot collect them. Usually the mature animals avoid such fruits, but sub-adults and juveniles collect them.

Animal food of bonnet macaques

Most of the animal food material eaten by the macaques were identified. The consumption of animal food material by the macaques was much less when compared with that of plant material. The animal food material consumption seems to be more in the adults than sub-adults and juveniles. An interesting animal item in the diet of monkeys was the garden lizard *Calotes versicolor*, observed once. Fast moving lizards and insects were hunted on trees and on the ground.

During May one adult male got hold of a *Calotes versicolor* and ate it bit by bit. The following animal material were taken by the macaques in different months during the study.

ANIMAL FOOD ITEMS OF BONNET MACAQUE

Species		Part consumed
Hapalia machaeralis (*larvae*)	..	whole
Phakopteron lentiginosum (Buckton)	..	whole
Catantops humilis Serv.	..	whole
Other Insects	..	whole
Calotes versicolor Daudin	..	whole

FEEDING BEHAVIOUR

The macaques started feeding early in the morning, usually between 0600 to 0900 hrs. They may start later during the cold weather. The macaques usually foraged leisurely sitting and walking. The animals fed in groups. But males, and particularly dominant males, preferred to feed alone though not far from the troop. They also fed more on the ground. Feeding location depended on the locality and time of the day. Early hours of the morning the animals prefer arboreal feeding. During the middle of the day the monkeys come down for feeding or for other activities. During the breeding season the mature animals eat more. Food was rarely transported by hand from one place to other. No animal offered food to another and no macaque was seen to use any tool to obtain its food. The infant monkeys tried to pick up the food discarded by their mothers. At times the infant took food from the hands of the mother. The monkeys remained close to each other while feeding on ground or on animal material. The macaques were very alert when they were on ground, especially the dominant males.

METHODS OF FEEDING

Bonnet macaques are selective feeders, consuming certain parts of certain fruits. The animals hoard food inside the cheek pouches when they are in a hurry to gather them or when disturbed. After filling the cheek pouches the animals run to shelter. This method is seen more frequently just before the mid-day rest. The hands of the macaques are used for manipulation, holding and pulling, and the teeth for biting and gnawing. The animals usually hold the fruits in hand or mouth and detach them from the branch. This method is clearly observed when the animals feed on *Derris glabra*, flower of *Salmalia malabarica* and fruit of *Anona squamosa*. After detaching the fruit from the branch the animals sit near-by and eat. One or both hands are used for plucking the fruits. The food is cleaned by rubbing between the palms or on rough tree surfaces. The former method is used while feeding on caterpillars and certain plants. When they feed on *Tamarindus indica* the macaques rub the entire fruit on a rough surface of the same tree branch, and then consume the unripe seeds. The same method was employed in the case of *Scutia myrtina*, *Manilkara hexandra* and *Carissa carandas*. Juveniles also use this kind of rubbing to open the fruit of *Derris glabra*. Occasionally the animal smells the food and throws it away. When feeding on the fruit of *Alangium salviifolium* the macaque plucks the fruit with the hand and squeezes it with its fingers and consumes the fleshy mesocarp and discards the seeds. They swallow small fruits as such. While feeding in open fields, the animals cover a wide area and search for grasshoppers and other insects by walking very slowly through the grasses or by lifting small stones. On many occasions it was noticed that the monkeys chase flying grasshoppers and other insects. Pupae and small insects attached to leaves were separated with the tongue and eaten, at times by licking. In the case of the gall farming psyllid (*Phakopteron lentiginosum*) the macaques pluck the leaves of *Garuga pinnata* with its attached gall, and carefully open it very near to the mouth by both hands and consume the psyllid. The macaques very carefully peel off the dead bark of trees by hand and search for animals.

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BANDING BATS FOR THE STUDY OF POPULATION ECOLOGY

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(*With two plates*)

INTRODUCTION

Studies involving banding of bats are mainly concerned with the homing abilities and migratory patterns of bats except for Pearson *et al.* (1952) who attempted to study the reproductive biology of *Corynorhinus rafinesquei* in nature employing wing banding. There are no systematic studies reported on either fluctuations in population or reproductive behaviour of bats in southern India. Keeping this in view the present study was undertaken. It concerned mainly with population fluctuation, colour polymorphism and reproductive behaviour of two species of microchiroptera : *Rhinolophus rouxi* and *Hipposideros speoris* from southern India.

METHODS OF STUDY

I. *Selection of banding site :* While selecting the banding site the following criteria were taken into consideration: (*a*) easy accessibility of bats at their day-time retreats and possibility of easy visual inspection of the roosting sites and (*b*) presence of alternative roosting sites within a short radius to enable recaptures, when necessary.

Srirangapatna (Karnataka State ; India : 12° 25 N′ 76° 40′ E) with abandoned subterranean magazines was selected as the banding area (Fig. 1). These magazines are totally dark during day-time and two species of microchiroptera, the Indian horse-shoe bat *Rhinolophus rouxi* (Rhinolophidae) (Fig. 2) and the leaf nosed bat *Hipposideros speoris* *(Hipposideridae) (Fig. 3) roost here. Both the species roost in one of the eight magazines, herein after referred to as G_1 and only *R. rouxi* roosts in two more magazines, herein after referred to as G_2 and G_3 (Fig. 1, G_1 to G_8). G_1 was selected as the banding site because of the availability of both the species of bats (Fig. 4). This magazine has an entrance leading to a landing five feet below the ground level which in turn leads to a lower landing at about 8′ below ground. A small arch entrance opens into the central corridor with a roof of about 12′ and two ante-chambers on either side with a low roof level and these are interconnected with three intercommunications on either side. The central corridor and ante-chambers are 6′ wide. There is a ventilator in the central corridor high above the ground level through which the bats move in and out freely (Fig. 5). Weekly trips were made to Srirangapatna for banding these bats from April 1974 to May 1975. There are hill ranges towards north and south-east of Srirangapatna situated at a distance of 15 Km. The hill range towards north is called Kuntibetta and the one towards south-east is called Karighatta. Several trips were made to these hill ranges to locate the banded bats.

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* Since the attempts to identify the species of *Hipposideros* were not successful, the diagnostic characters of the specimen collected are given herewith :

Head length : 1.8 cm ; Body length : 4.4 cm ; Wing span : 32.5 cm ; Fore arm length : 2.1 cm ; Tail length : 3.5 cm.

II. *Banding material and procedure :* Thin aluminium foils with numbers engraved and cable wire together weighing 200 to 250 mg were used for banding. The bats were captured with a butterfly net without causing injury.** The wire with the numbered foil was placed around the neck of the bat and the free ends were twisted. Care was taken to see that the band does not slip out easily and does not suffocate the animal.

Ear was punched as an additional mark of recognition so that even if the band is lost the bat can always be identified as a previously banded bat.

The body weight, species, sex, fur colour and the reproductive status of each animal were recorded. Vaginal smears of only *R. rouxi* were examined while, *H. speoris* were not available for such examinations.

Some bats, brought from G_2 and G_3, were banded and released at G_1 during some months. These magazines were visited regularly to trace the banded bats. 25 bats were brought from G_3 to Paschimavahini situated at a distance of 1.6 Km South-west of G_3, were banded and released to test the homing abilities.

The percentage of recaptures has been calculated as : (*a*) cumulative percentage which is expressed as the percentage of the total recaptures to the total number of bats banded upto the previous week and (*b*) relative percentage which is expressed as the percentage of the number of bats recaptured on any given date to the total number of bats captured on that date (includes both banded and recaptured) (table 1).

Some discarded bands were recovered from G_1. Two reasons could be ascribed to account for this : (*a*) defective banding where the bands were recovered with the cable wire ring intact and (*b*) chewing of the wire where the bands were recovered either with a cut in the ring or the ring intact without band. The percentage of such recoveries to the total number of bats banded is included here as failure rate (table 2).

The frequency of recaptures was calculated in relation to : (*a*) the number of times the same bat was recaptured and (*b*) the period after which the bat was recaptured (period between banding and recapture) (table 3).

OBSERVATIONS

A total of 1193 bats were banded during a period of 14 months (Tables 1 and 2). The banded bats were recognizable from a distance of three to five metres at their day-time retreats (Fig. 6) with a large number of non-banded bats. Even without seeing them, the existence of banded bats could be clearly made out, since, the band makes a rustling noise as the disturbed animals hung themselves back at their perch. Bands could be recognised even after a lapse of 13 months and the numbers were not disfigured. Continuous contact with the cable wire or the aluminium foil did not cause any skin reaction in recaptured bats. The band does not seem to interfere with the normal activities of the bats, since, bats recaptured even after one year were found to be normal. Young bats, which are two to three months old, can also be successfully banded.

The hole caused by punching the ear heals and closes leaving a white circular scar which can be seen by fifth week (Fig. 7) and this later becomes pigmented and indistinguishable.

The average rate of recaptures of banded bats is almost the same per any given week (Table 1). Except for some days it is observed that the relative percentage of recaptures is always greater than the cumulative percentage of recaptures. It is important to note that in spite

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** Capturing bats under these conditions using butterfly net will : 1. cause a certain amount of injury to bats and 2. cause much panic among the individuals providing bias in the recapture data—EDS.

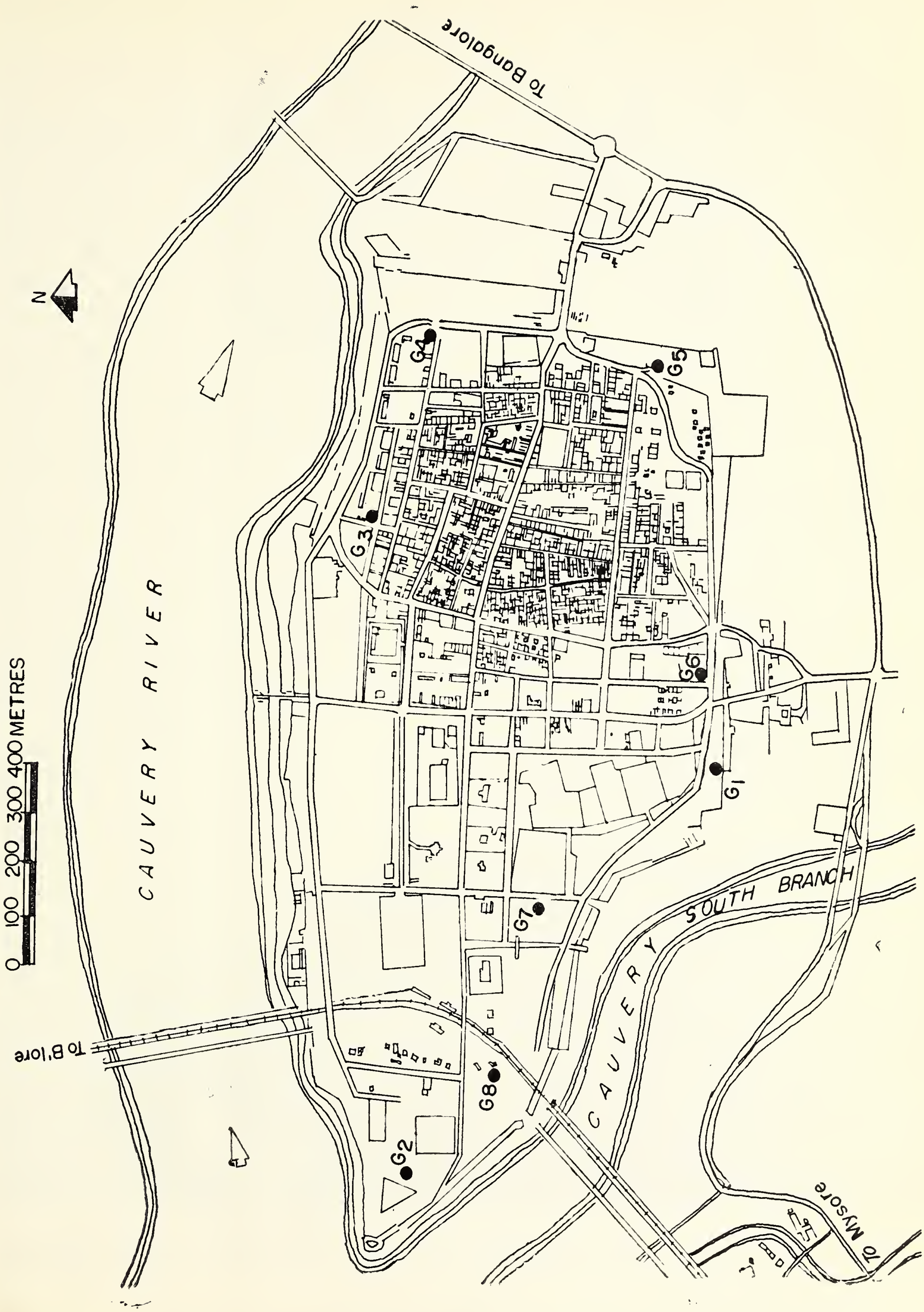
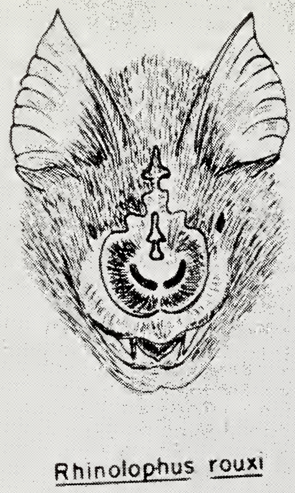

To Bangalore
N
0 100 200 300 400 METRES
CAUVERY RIVER
G1
G2
G3
G4
G5
G6
G7
G8
To B'lore
CAUVERY SOUTH BRANCH
To Mysore

Fig. 1. Map of Srirangapatna showing the eight magazines marked G_1 to G_8.



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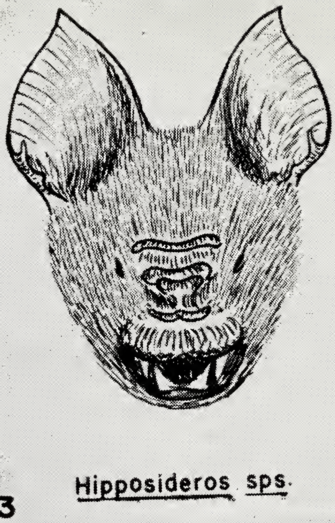
Hipposideros sps.

3

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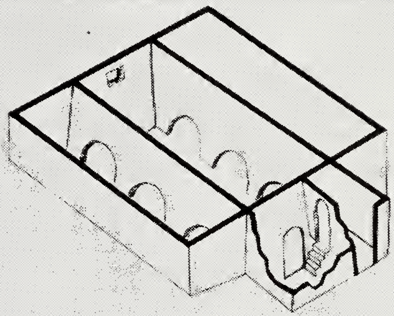

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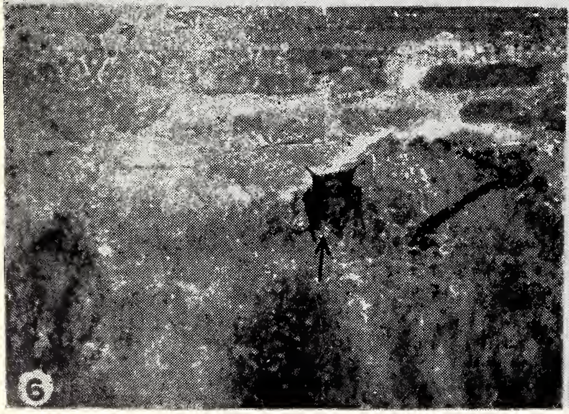

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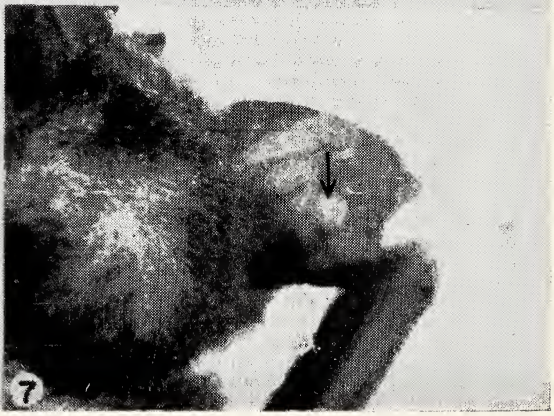

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Fig. 2. Face of *Rhinolophus rouxi*. Fig. 3. Face of *Hipposideros speoris*. Fig. 4. A view of the magazine G_1.

Fig. 5. Sectional view of the magazine G_1 showing the two landings, central hall, two lateral corridors with their interconnections and ventilator.

Fig. 6. A banded bat clinging to the wall. Arrow indicates the band.

Fig. 7. Ear of a bat to show the white scar formed after punching. Arrow indicates the scar.

TABLE 1

DETAILS OF BANDING AND RECAPTURES

Month & Date		Banding		Recaptures			
		Abs.	Cum.	Abs.	Cum.	Percentage	
						Cum.	Rel.
April	14	76	76	—	—	—	—
	21	76	152	13	13	17.1	14.6
May	5	67	219	14	27	17.7	17.2
	12	68	287	11	38	17.3	13.9
	19	54	341	8	46	16.0	12.9
	26	38	379	14	60	17.5	26.9
June	9	115	494	17	77	20.3	12.9
	23	18	512	4	81	16.4	18.2
July	7	83	595	11	92	17.9	11.7
	14	77	672	8	100	16.8	9.4
	21	36	708	21	121	18.0	36.8
August	4	75	783	23	144	20.3	23.5
	11	60	843	21	165	21.1	25.9
	18	93	936	6	171	20.3	6.1
September	1	24	960	7	178	19.0	22.6
	15	35	995	10	188	19.6	22.2
	29	46	1041	7	195	19.6	13.2
			NO BANDING*				
Oct. to Nov.	3	26	1067	6	201	19.3	18.8
	10	23	1090	5	206	19.3	17.8
	17	7	1097	5	211	19.3	41.7
	24	25	1122	10	221	20.1	28.6
Dec. to March			NO BANDING*				
April	6	20	1142	6	227	20.2	23.1
	20	17	1159	3	230	20.1	15.0
May	18	22	1181	12	242	20.8	35.3
	26	12	1193	6	248	20.9	33.3

* No banding, since the animals were not to be found.

Abs. = Absolute ; Cum. = Cumulative ; Rel. = Relative.

TABLE 2

BANDING AND RECAPTURES (MONTHWISE), MORTALITY RATE, AND FAILURE OF BANDING

Particulars	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec. to Mar.	Apr.	May
I. Number banded											
(*a*) Absolute ..	152	227	133	196	228	105	No banding+	81	No banding+	37	34
(*b*) Cumulative ..	—	379	512	708	936	1041		1122		1159	1193
II. Recaptures											
(*a*) Absolute ..	13	47	21	40	50	24		26		9	18
(*b*) Cumulative ..	—	60	81	121	171	195		221		230	248
(*c*) Percentage											
i. Cumulative ..	17.1	17.5	16.4	18.0	20.3	19.6		20.1		20.1	20.9
ii. Relative ..	14.6	17.1	13.6	16.9	17.9	18.6		24.2		19.5	39.6
III. Mortality*											
(*a*) Due to banding ..					4@						
(*b*) Unknown reasons ..					17						
(*c*) Total ..					21						
(*d*) Percentage ..					1.7						
IV. Failure of banding*											
(*a*) Chewing of wire ..					43						
(*b*) Defective banding ..					9						
(*c*) Total ..					52						
(*d*) Percentage ..					4.4						

* Data pooled.

@ Only juveniles of recent birth.

+ No banding, since the animals were not to be found.

TABLE 3

FREQUENCY OF RECAPTURES

Frequency	Recaptured after (in months)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Once ..	79	41	13	8	3	3	1	2	1	—	—	1	1	—
Twice ..	4	9	8	4	2	—	1	—	—	—	—	—	1	—
Thrice ..	—	4	1	2	—	—	1	—	—	—	—	—	—	—
Four times ..	—	—	1	1	1	—	—	—	—	—	—	—	—	—
Five times ..	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Unaccountable* ..	—	—	2	—	4	4	5	—	—	—	—	—	4	11

Note.—Bats recaptured on the same day of banding are not taken into account.

* Bats recaptured with the wire ring intact, but the band missing.

of increased number of banded bats, the cumulative percentage of recaptures remains almost the same. Daily inspection of G_3 for 7 days revealed that of the bats taken from G_3 banded and released at Paschimavahini, very few returned to G_3. Only one bat was recaptured at G_3 on the following day after release and two bats were recovered on the second day. Later recoveries were nil and even these three bats were not to be found at G_3 later on.

The number of recaptures in relation to the period after banding decreases after a lapse of time. In the first month after banding recaptures were relatively high and the rate gradually decreases as the duration between banding and recaptures increases (Table 3). Multiple recaptures are very few. Recapture for the second time is more frequent during the first three months. In this connection it is very interesting to note that one bat was recaptured in the same magazine (G_1) after 13 months !

Some bats without the bands but with the wire ring intact around the neck were also captured. These are also considered as recaptures. But the frequency of recaptures in relation to the number of times or to the period from the date of their banding to the date of their recapture cannot be calculated, since the reference to these bats as to the date on which they were banded cannot be traced. Hence these are treated as 'unaccountable' in Table 3.

Bats banded at G_1 were occasionally recatpured at G_2 and G_3 also. Of the 200 bats brought from G_2 and G_3, banded and released at G_1, only two were recaptured at G_2 and five at G_3.

The word population is used here with a specific meaning to indicate the number of bats occupying the given magazine at a given time. The number of bats banded during each week and month is given in Tables 1 and 2, respectively. A wide fluctuation in the number of individuals occupying the magazine is observed. During October-March period except November, bats were not found in any of the magazines. Our efforts to locate the bats during this period at other alternative sites were not successful. As Karighatta is relatively smooth and devoid of cave formations no bats were found there. At Kuntibetta, there are many cave formations and rock crevices.

R. rouxi roost in these crevices and caves but banded bats were not seen. *R. rouxi* when available, were found congregating in large numbers both at Kuntibetta and Magazines.

During the course of the study some dead banded bats were recovered (Table 2). Of these, four were very young and they died of strangulation due to banding.

The sex ratio (Table 4) indicates that both sexes co-exist in the same roost. Female *R.rouxi* were not found during April, but they appear during May and out-number the males during June-August and then decline. On the other hand, both the sexes of *H. speoris* occupied the magazine in large numbers during April and May and both decrease in number afterwards. They reappear only during next April. The ratio of the number of *R. rouxi* to the number of *H. speoris* living in the same magazine is always greater, except during April.

Colour polymorphism prevails in both the species of bats (Table 5). They exhibit brown (melanistic) to bright orange (erythristic) coloured fur. Bats with mixed colour patches were also observed.

Orange furred bats appear in May and continue upto September. The ratio of melanistic bats to the erythristic bats in two species or to the total number of bats banded indicates that there are more orange furred *R. rouxi* than *H. speoris*. Orange furred *H. speoris* were found only during April and May (1974) and April (1975) and their relative percentage to the total number of bats banded during those months is only 0.7, 1.8 and 2.7 respectively. Orange furred *R. rouxi* appear during April, gradually increase in number during May and out-number the melanistic forms during June and August. Then they decline and disappear during November and reappear during next April.

Cornified scales were noticed in the vaginal smears of *R. rouxi* during September-November period. *H. speoris* females collected during April were pregnant and were lactating during the middle of May. The young ones leave their mothers and lead an independent life two to three weeks after their birth. The higher incidence of *H. speoris* indicates that this species roosts in this magazine for breeding activities. They decline in number afterwards and reappear only during next April. The juveniles of this species remain sexually immature even one year after birth.

The body weights are indicated in Table 6. It is evident that there is a fast rate of growth in these species and that there is not much of a difference between the body weights of adults and juveniles. Further, there is no appreciable change in the weights during different months of the year. Comparatively *R. rouxi* is a heavier animal with a body weight range of 15.0 to 18.5 gm while, *H. speoris* weight range is 9.0 to 15.2 gm. In *R. rouxi*, there seems to be a difference between the two sexes and the female weighs a little less than the males while, in *H. speoris*, there is no significant difference between the two sexes.

The weights of the newly born *H. speoris* ranges from 5.3 to 7.3 gm which represents 38.3% of the body weight of adult animals. 11 to 15 days after their birth, the young ones weigh on average, 7.4 gm. Within two to three months after their birth, the weights of juveniles is almost the same as that of the adult animal. We could not make similar observations in *R. rouxi* as we could not collect newly born horse-shoe bats.

DISCUSSION

The recapture rate in the present study is encouraging (Tables 1 and 2). The failure rate does not seem to give an accurate picture as we were able to recover the discarded bands only from the magazine (Table 2). Mortality among adults due to banding seems to be nil from available data.

Table 4

Sex ratio and Population density

Species & sex	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec. to Mar.	Apr.	May
					SEX RATIO						
R. rouxi											
Male	67	118	31	62	35	26		42		8	7
Female	—	21	82	121	191	68		36		—	—
Hipposideros speoris											
Male	49	26	15	5	1	2	No banding+	3	No banding+	19	9
Female	36	62	5	8	1	9		—		10	18
					POPULATION DENSITY*						
R. rouxi	44	61.2	84.9	93.4	94.7	89.5		96.3		21.6	20.6
Hipposideros speoris	56	38.8	15.1	6.6	5.3	10.5		3.7		78.4	79.4

* Expressed as the percentage to the total number of bats banded during that month.

+ No banding, since the animals were not to be found.

TABLE 5

RELATIVE PERCENTAGE OF COLOUR POLYMORPHISM AMONG BANDED BATS

Species & Colour	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec. to Mar.	Apr.	May
R. rouxi											
(*a*) Melanistic fur	66+ 95.5* 43.4@	110 79.1 48.4	36 31.9 27.0	101 55.2 51.1	83 36.7 36.4	51 54.3 48.6		54 98.4 96.4		8 80.0 21.6	7 100 20.6
(*b*) Erythristic fur	1 4.5 0.7	27 19.4 11.9	75 66.4 56.4	80 43.7 40.8	139 61.5 60.9	29 30.8 27.6		1 1.8 1.8		2 20.0 5.4	— — —
(*c*) Mixed fur	— — —	2 1.5 0.9	2 1.7 1.5	2 1.1 1.0	4 1.8 1.8	14 14.9 13.3	No banding[1]	— — —	No banding[1]	— — —	— — —
Hipposideros speoris											
(*a*) Melanistic fur	84 98.8 55.2	84 95.5 37.0	20 100 15.1	13 100 7.1	2 100 0.9	11 100 10.5		1 100 1.8		26 96.5 70.3	27 100 79.4
(*b*) Erythristic fur	1 1.2 0.7	4 4.5 1.8	— — —	— — —	— — —	— — —		— — —		1 3.5 2.7	— — —
(*c*) Mixed fur	—	—	—	—	—	—		—		—	—

+ Absolute number of bats banded.

* Relative percentage to the total number banded in that species during that month.

@ Relative percentage to the total number of bats banded during that month.

[1] No banding, since the animals were not to be found.

TABLE 6

AVERAGE BODY WEIGHT (IN GM) OF *R. rouxi* AND *Hipposideros speoris* DURING DIFFERENT MONTHS AT VARIOUS REPRODUCTIVE STAGES

Species		Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec. to Mar.	Apr.	May
R. rouxi												
Male :	Adult	15.8	17.3	15.3	15.8	15.0	15.8		16.1		17.0	18.5
	Juvenile	15.2	—	13.7	13.6	14.1	14.4		14.2		—	—
Female :	Adult	—	14.3	13.0	13.9	12.7	13.2		14.0		—	—
	Juvenile	—	15.5	13.3	13.0	12.7	13.2		13.6		—	8.5
Hipposideros speoris												
Male :	Adult	12.3	12.5	12.5	12.7	—	—	No banding+	—	No banding+	13.7	15.2
	Juvenile	—	11.0	9.1	10.0	9.0	14.5		—		—	—
Female :	Adult	—	12.9	13.1	12.4	—	14.5		—		13.7	—
	Juvenile	13.4	12.0	—	8.3	—	—		12.0		—	—
	Pregnant	14·4	17.0	—	—	—	—		—		16.3	17.1
	Lactating*	—	16.6	—	—	—	—		—		—	17.6

* Includes the weight of the young ones clinging to their mothers.

+ No banding, since the animals were not to be found.

Punching ears as an additional mark of recognition does not seem to be useful since, the perforation heals within a short period and becomes indistinguishable. This confirms the uselessness of marking ears (Griffin 1970).

Keeping in view all the advantages of neck banding, it may be said that the technique is useful in keeping track of individual bats.

The cumulative percentage of recaptures remains almost the same throughout the duration of this study. It is interesting to note that in spite of progressive increase in the total number of bats banded, the cumulative percentage of recaptures for any given date remains almost the same (Table 1). This is due to the continuous influx of new occupants to the magazine and it is evident that not all the bats banded in the previous week return to the same magazine after their nocturnal activity. It is interesting to observe that the banded bats are very few even in other two magazines which are situated at a very short distance. Abel (1960) reported very little shifting between two well populated colonies of *R. ferrum-equinum* and pointed out that the colonies were rather stable. Similarly Pearson *et al.* (1952) reported that almost all the banded *Corynorhinus rafinesquei* were recaptured at the same place. Contrary to this, Roer (1960) observed a rapid movement of colonies of *R. ferrum-equinum* and *R. hipposideros* between several roosts situated within a short radius. The colonial make up of *R. rouxi* seems to be highly unstable as evidenced from our present study. Recapture of bats brought from G_2 and G_3, banded and released at G_1 are very few. The frequency of recapture both in relation to the number of times of recapture and the time lag indicate no specificity for any day-time retreat contrary to those reported for some European congeneric species (Griffin 1970). All these suggest that the territory of *R. rouxi* in the present study is much larger than the area that could be covered by these three magazines. Because of the wide fluctuation in the number of bats in any magazine on any given date, it may be said that these bats migrate frequently over short distances (local migration or local movement) which is an important part of the behaviour of bats.

On the other hand, *H. speoris* occupy the magazine only during late pregnancy and lactation period and move away at the end of the lactation period. At present it is not possible for us to locate their roosts during non-breeding and early pregnancy periods. A similar situation has been reported by Davis *et al.* (1962) for *Tadarida brasiliensis* where the summer roosts consist of pregnant females and lactating mothers. They also reported that the mothers do not carry their young ones when they leave the roosts for hunting and a sort of communal dairy herd has been established as for as lactational behaviour is concerned. But in the present study, the mothers carry their young ones during nocturnal activities and this lactational behaviour is different from that of *Tadarida brasiliensis.*

Males and females of *R. rouxi* roost together during non-breeding season and there seems to be no sexual isolation contrary to the reports on European congeneric species. *R. rouxi* comes to oestrus during November as revealed by the presence of cornified scales in the vaginal smears. This agrees with the reports that *R. rouxi* gives birth during March-April (Asdell 1964). Our observations that *R. rouxi* are not to be found during December to March suggest that they might have a different breeding area.

It has been reported that the young bats range from 15 to 30 per cent of the weight of the adults (Orr 1970). In the present study the newly born *H. speoris* weighed on average 38.3 per cent of the adults followed by a gradual increase in the ratio as the growth proceeds (Table 6). The juveniles become indistinguishable from the adults in their body size within three months of their birth. This indicates a rapid growth rate among these bats.

There is some controversy as to the age at which the bats attain sexual maturity (Orr 1970). Based on banding data Shearman (1937) observed that *Tadarida cynocephala* reached sexual maturity within one year after birth and according to him the females of this species came to oestrus within one year. Ramakrishna (1976) suggested that *R. rouxi rouxi* attains sexual maturity only after a year. Our data indicates that *H. speoris* do not attain sexual maturity by the first year of their birth as newly born young bats banded during July 1974 remained sexually immature even after one year.

Colour polymorphism has been reported in rhinolophids and leaf nosed bats (Walker *et al.* 1968). This colour polymorphism does not seem to be associated with breeding cycles or sexual status of the bat (at least in *R. rouxi*), since both melanistic and erythristic forms of juveniles and adults of both the sexes occur throughout the year although Anderson (1917) indicated that the darkness of the fresh coat fades away with age, sex and other factors like ammonia concentration at the roosting site. Quay (1970) concluded that there should be a high incidence of colour polymorphism during late summer. But in the present study, the incidence of polymorphism is high during monsoons (rainy season). Since both melanistic and erythristic forms and mixed fur coloured forms occur together in the same magazine, it may be possible that this colour polymorphism may be genetic. But it is very difficult at this stage to suggest whether this colour polymorphism is entirely genetic or the animals change the colour in relation to the concentration of ammonia in the roosting sites (which we have not measured).

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THE STATUS AND DISTRIBUTION OF ELEPHANT POPULATIONS OF KARNATAKA

P. Vijayakumaran Nair and Madhav Gadgil[1]

(*With four plates and seven text-figures*)

INTRODUCTION

The hill chain of Western Ghats running parallel to the west coast of India is a fascinating region from both an ecological and biogeographical point of view. The extensive hilly region retains its natural vegetation and fauna to a much greater degree than the rest of the peninsula. This last refuge of the natural fauna and flora is, however, being threatened with rapid destruction by the numerous hydro-electric and irrigation projects that are coming up, the greatly accelerated pace of forest exploitation and the increasing demand for land for plantation and cultivation. As a consequence very few virgin forests remain intact on the western ghats today and the wild life has also been nearly wiped out. It is therefore an urgent need of the day to make an accurate assessment of the status of the natural vegetation and wild life of this area. A report dealing with the natural vegetation of the Karnataka region of this area and man's impact on it has been submitted as a report to the Task Force on the Ecological Planning of Development of Western Ghats (Prasad, Nair, Sharatchandra and Gadgil 1977). The present report deals with the wild life of the Karnataka region of this area with particular emphasis on the elephant populations.

METHODOLOGY

The Western Ghats areas of Karnataka along with the eastward extension of hills across the Mysore plateau may for purposes of description be divided into the following five areas : (*a*) North Kanara, (*b*) Crest line of the Western Ghats, (*c*) Malnad, (*d*) Mysore plateau, (*e*) Kollegal hills (Figure 1).

The present report is based on studies carried out in Karnataka over a period of more than three years from May 1974 to July 1977. Over these three years we have maintained almost continuous detailed observations at Bandipur National Park. This has been supplemented by an intensive survey of the Mysore plateau from July to October 1975, a survey of North Kanara area from August 1976 to January 1977 and a survey of the Malnad, Crestline and Kollegal areas from May to July 1977.

Different methods were adopted in the different areas depending on the circumstances and aims of the study. The first intensive survey of the Mysore plateau was conducted by a party of four biologists who covered the terrain on foot. The survey area was divided into approximately ten square kilometre compartments with the aid of maps and each of the compartments surveyed by one investigator with the help of a local guide. Walking in a zig-zag route the entire terrain, especially areas favoured by elephants such as swamps, stream banks, and bamboo thickets were traversed. Whenever elephant herds were encountered details of the herd composition were noted. The distribution and degree of abundance of other wild life, based on sightings as well as on spoor marks was recorded. Particular attention was paid to elephant tracks and dung to infer the number in the herd involved. A

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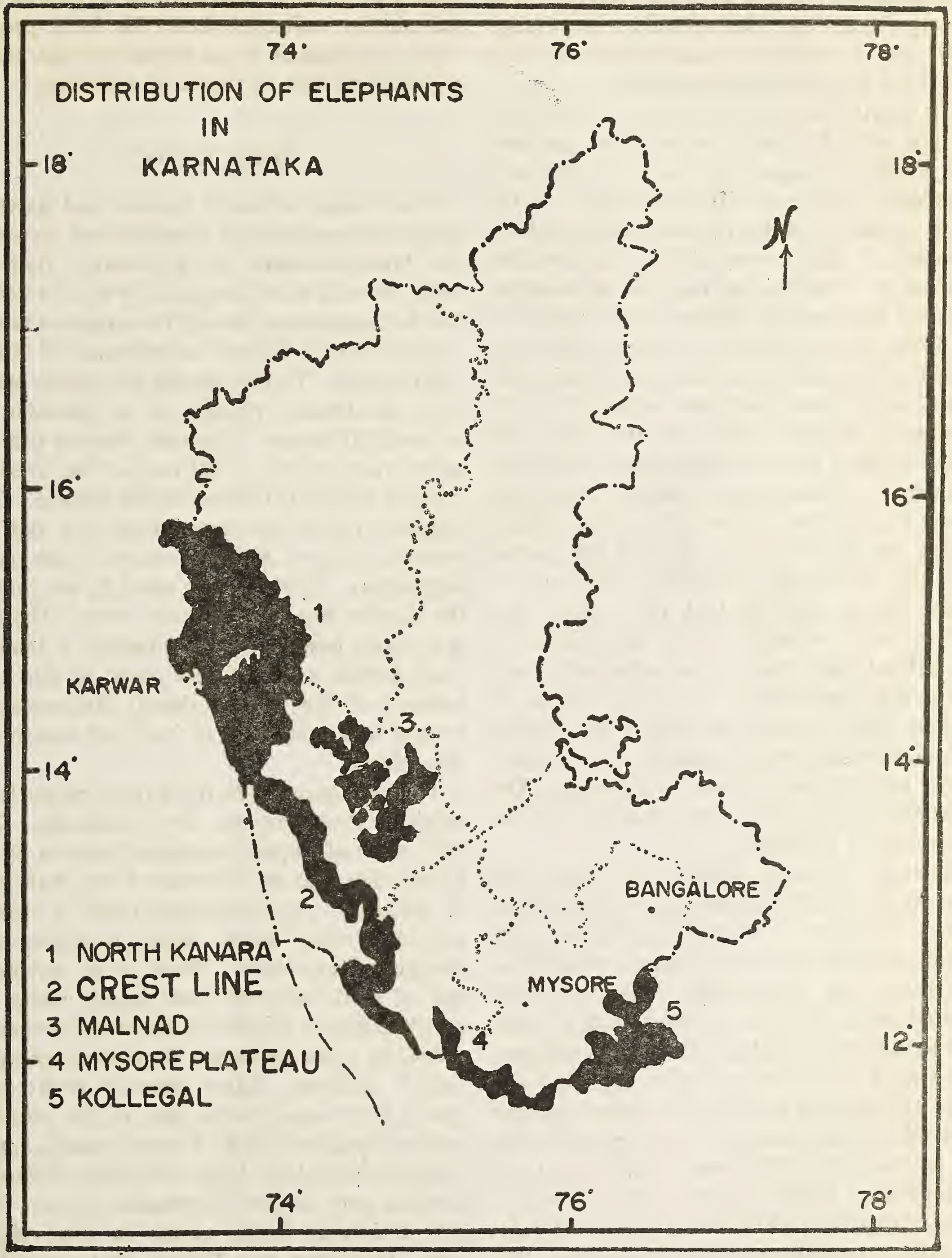

74°
76°
78°
DISTRIBUTION OF ELEPHANTS
IN
KARNATAKA
18°
18°
N
16°
16°
1
KARWAR
3
14°
14°
2
BANGALORE
MYSORE
5
4
12°
12°
1 NORTH KANARA
2 CREST LINE
3 MALNAD
4 MYSOREPLATEAU
5 KOLLEGAL
74°
76°
78°

Fig. 1. Map of Karnataka forests showing the five elephant bearing areas.

detailed account of this work has been published already, (Nair, Nair, Sharatchandra and Gadgil 1977) but a resume is incorporated in this report for the sake of completeness.

The North Kanara forests are vast, and now contain wild life only in scattered pockets. The elephants in particular are very few and completely dispersed. Tracking them in the dense vegetation of this region would have been impossible in the time available. We therefore resorted to collecting the required information from the innumerable hamlets in the middle of the forest where elephants regularly raid crops. Almost all the villages inside and bordering the forests were visited and data collected on the number of elephants that raid the crops, the season of their visits and the general pattern of movement. Wherever possible this was confirmed by checking on elephant tracks. Information on the abundance of wild life species was also collected during the same visits. These details were plotted on a map and analysed with reference to the distribution of the habitat and barriers to movements and provided a good picture of the distribution of elephant herds as well as other wild animals. A similar method was adopted for the Western Ghats areas from Makut to Bhatkal. The investigation here was faster because of the availability of a vehicle.

Basically the same method was used with more detailed field observations in the Malnad areas. The number of elephants here is much greater and the vegetation more favourable for movement and observation. The forest was covered in detail mostly in the vehicle in addition to collecting information from the villagers. The tracks and other spoor of elephants and other wild animals as well as the actual sightings were taken into account. The Kollegal areas are extensive dry hilly tracts which could not be covered in sufficient detail. This area has a number of elephants which move to and from the Sathyamangala areas of Tamil Nadu. The area was covered rapidly with a vehicle and information collected from the local people. This was checked to an extent through actual sightings as well as tracks of elephants.

NORTH KANARA

The district of North Kanara and parts of Belgaum constitute the northernmost sector of the Western Ghats in Karnataka (latitude 13°45′N to 15°45′N, longitude 74°E to 75°15′E). The hill ranges run through this area in a north-south direction rising to an elevation of 700 to 1000 metres. To the east the hill ranges merge into the Deccan plateau at an elevation of around 600 metres. The tract receives precipitation ranging from 6500 mm at the crest of the hills to about 1000 mm on the plateau. The Western Ghats are very broad here and the extensive hilly terrain is covered with good vegetation. Until recently about 80 per cent of the district was under forest cover. The last few years, however, have witnessed a tremendous decline of the forest cover in this area because of the giant Kalinadi Hydro-electric Project and great deal of iron and manganese ore mining.

The vegetation of North Kanara ranges from tropical evergreen to dry deciduous. The only patch of tropical evergreen forest in North Kanara lies near the crestline of the ghats west of Siddapur. This evergreen forest is characterized by *Olea dioica*, *Hopea wightiana* and *Diospyros canolleana*. There is an extensive belt of semi-evergreen forest largely along the crestline and to the west of the crestline characterized by *Xylia xylocarpa*, *Terminalia tomentosa* and *T. bellerica*. Large tracts of moist deciduous forest occur to the east of the crestline and are characterized by *Tectona grandis*, *Lagerstroemia lanceolata*, *Xylia xylocarpa*, *Dalbergia latifolia* and various *Terminalia* species. The dry deciduous forest occurs in low rainfall areas bordering the Deccan plateau and is characterized by *Anogeissus latifolia, Tectona grandis, Grewia tiliaefolia* and *Terminalia tomentosa.* There is a good bamboo growth through much of this area. With such rich vegetation, there is no shortage of fodder for elephants of this region.

This is one of the richer wild life areas in the state and can boast of elephants, gaur, sambar, spotted deer, wild pig, wild dog, panther and tiger. Gaur are now to be frequently seen in only restricted areas such as Virnoli range, western parts of Dandeli range and parts of Supa range. Tiger is widely destributed and frequently makes cattle kills particularly in parts of Mundgod range, Kirwatti range and Gund range.

Elephant population

The district of North Kanara lies at the extreme northern end of the distribution of the Asiatic Elephant on the Western Ghats in Peninsular India. Geologically also this district constitutes the northernmost limit of the precambrian igneous rock formation. Whether this coincidence of the geological regime and its consequent vegetational regime and of the elephant distribution has any further significance is not known. In recent past at least the elephants were distributed through most of the North Kanara district to the east of the crestline of the Western Ghats. That is to say their distribution largely coincided with the moist and dry deciduous vegetation. They seem to have been largely absent from the coastal tract and the hill tract to the west of the crestline which receives very heavy rainfall and harboured very dense semievergreen vegetation. The elephant population of this district earlier in this century seems to have comprised five different herds, two of which still survive as herds with males and calves. Two others seem to have been reduced to one or two bulls and the fifth one has been completely wiped out (see fig. 2).

Herd 1 : The 1957 working plan mentions the existence of a herd staying in the Barchi valley and moving through the adjoining forests of Nagargali. This herd still survives and includes about eight to ten animals. The herd spends the summer months in the moister Kurundi and Nagargali forests near Jagalbet, Nagargali areas. The last decade has witnessed the release of a number of revenue forest lands for cultivation within the range of this herd. Apparently the cultivators did not suffer much from crop raiding by this herd in the initial years of cultivation. Huge areas within this range have recently been cleared in connection with Supa dam of the Kalinadi hydro-electric project as well as for manganese mining. This has led to the elephants being forced into contact with the cultivated areas with much raiding of crops in villages like Barchi, Shingergaon, Kudilgaon, Aveda, Kheda, Bommardo, Ajgaon, Usoda, Badgund, Gobral, Vaini, Adangaon etc. in the years 1975 to 1977 (see fig. 3).

Herd 2 : Korlhally (1957) refers to a bigger herd staying in the Kaneri river valley. This herd used to spend the drier months in the Kaneri and Nagjhari river valleys and used to range in the Dandeli, Bhagavathi, Ambga Jumba (present Ambikanagar), Phansoli, Gund, Ulvi, Ganeshgudi areas as also towards Hunasgere, Kolikere, Kirwatti side. In the distant past they used to go as far as Kalghatgi. The last three decades since independence have witnessed a great deal of cultivation particularly towards the Yellapur side being taken up. This herd apparently used to raid the crops in its range and was shot. There is hardly a village within the range of this herd where one or two elephants have not been shot since 1947. When the paper mill was established in Dandeli area elephants used to come right upto the township of the mill and were shot there. By about 1965 this herd was reduced to three to five animals. One more elephant was reported

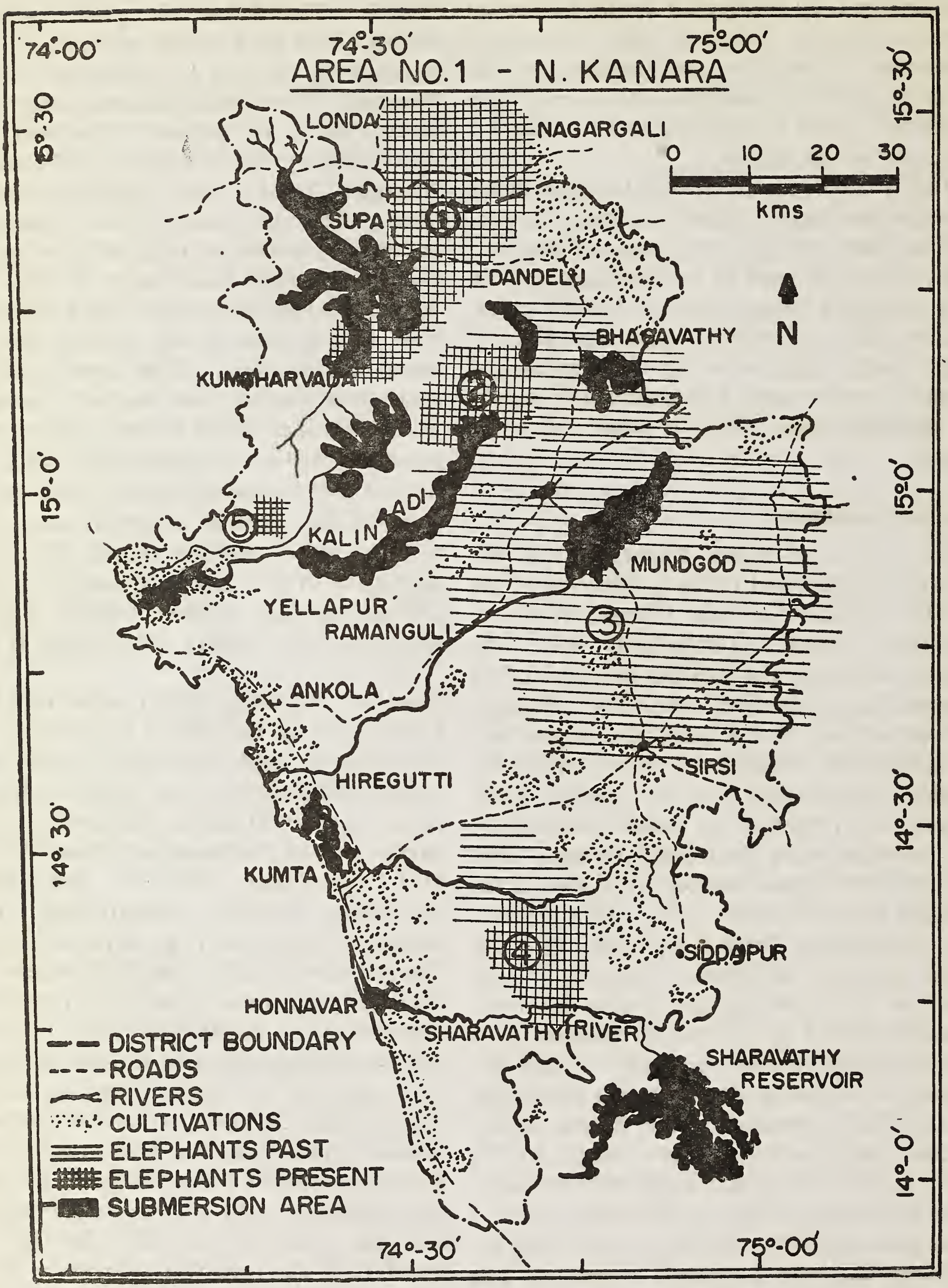

AREA NO.1 - N. KANARA
74°-00'
74°-30'
75°-00'
15°-30'
15°-0'
14°-30'
14°-0'
LONDA
NAGARGALI
SUPA
DANDELI
BHAGAVATHY
KUMBHARVADA
KALINADI
MUNDGOD
YELLAPUR
RAMANGULI
ANKOLA
SIRSI
HIREGUTTI
KUMTA
SIDDAPUR
HONNAVAR
SHARAVATHY RIVER
SHARAVATHY RESERVOIR
①
②
③
④
⑤
0 10 20 30
kms
N
DISTRICT BOUNDARY
ROADS
RIVERS
CULTIVATIONS
ELEPHANTS PAST
ELEPHANTS PRESENT
SUBMERSION AREA

Fig. 2. Distribution of elephants in North Kanara.

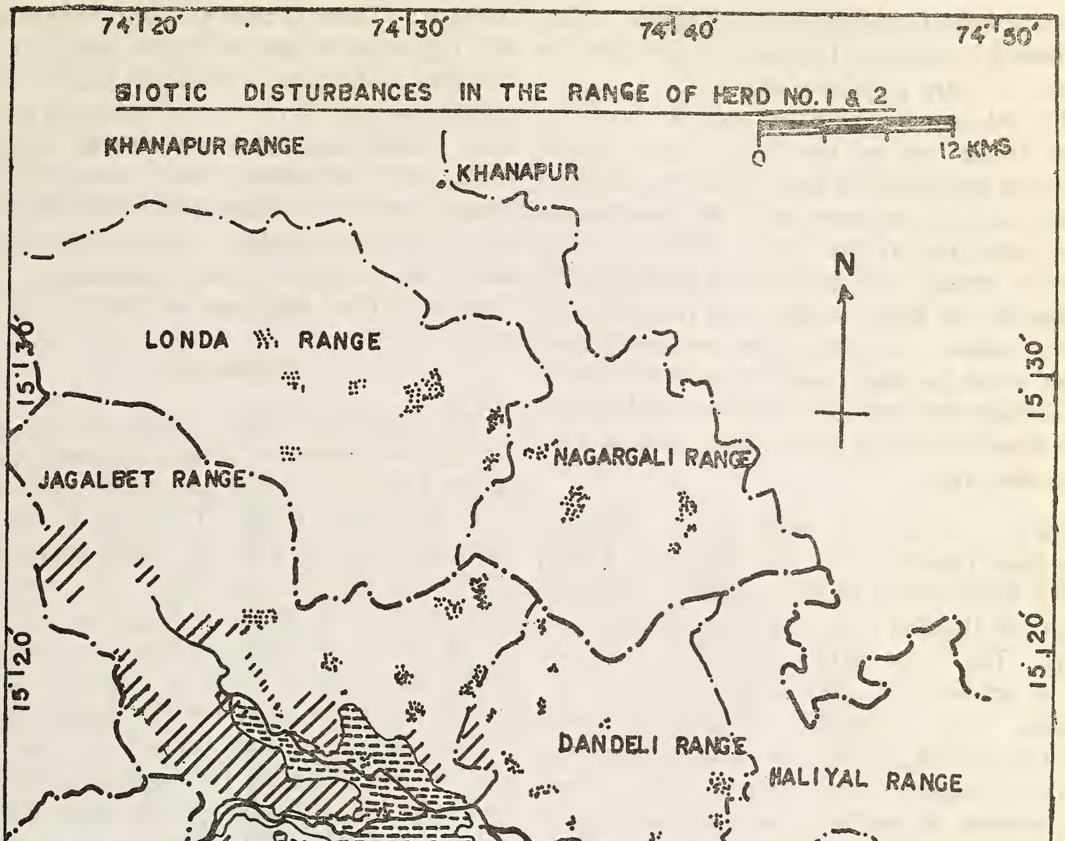

BIOTIC DISTURBANCES IN THE RANGE OF HERD NO. 1 & 2
74°20'
74°30'
74°40'
74°50'
15°30'
15°20'
15°10'
15°00'
0
12 KMS
N
KHANAPUR RANGE
KHANAPUR
LONDA RANGE
JAGALBET RANGE
NAGARGALI RANGE
DANDELI RANGE
HALIYAL RANGE
SAMBRANI RANGE
SUPA RANGE
VIRNOLI RANGE
KULGI RANGE
GUND RANGE
YELLAPUR DIVISION
DIVISION BOUNDARY
RANGE BOUNDARY
RIVERS & STREAMS
SUBMERSION AREA
MINES
CULTIVATION INSIDE FOREST & CROP RADING

Fig. 3. Maps of Haliyal, Yellapur and Karwar divisions indicating the various disturbances affecting the forest habitat and the elephant populations.

to have been found dead near Nagjhari valley around 2 years ago. This year we have seen the tracks of only a solitary elephant.

It is interesting to note that when the first herd was driven out of the Supa forest people believed them to have come from the Nagjhari area where the construction of the power-house had begun just at that time. However, a big belt of villages and cultivations separates the range of the herd number two from that of herd number one. Since no elephants have been noted to have passed through this belt it is unlikely that any animals from herd two of the Nagjhari valley could have crossed over into that area.

Herd 3 : A herd of eight to ten elephants has been reported from the Mundgod, Katur, Bilki, Manchikere, Bharathanahally, Chevathy, Sirsi and Hulekal areas in the pre-independence days. The forest in this entire belt is riddled by a net-work of cultivation throughout the region. Such cultivation is highly susceptible to crop raiding by elephants and the elephants were consequently completely shot out. There are records of elephants having been shot at Katur, Mundgod, Bharathanahally, Pala, Attangi, Chipgeri, Indoor, Chevathy, Sirsi etc. The complete herd was eliminated about 30 years ago.

Herd 4 : There is presently a herd of a few elephants and a solitary bull in the Gersoppa region. They range over Badal, Jankadkal, Medni, Herebail, Mahime, Gersoppa areas. This herd has also received some recruits from the Linganamakki submersion area of the Sharavathy hydroelectric project. The herd is extensively utilizing the scrub forests created by human interference which cover the hilly terrain towards the coast. The climax forest in this region is semievergreen which persists towards the more interior parts of the range. Two elephants were found shot dead on the bank of Sharavathy river in May 1979.

Herd 5 : There is now a solitary elephant in the Ghotegali region in Kadra range in the Sanake, Hajkarni, Bargadde areas. This elephant probably moves into the Goa forests also. There was apparently another elephant along with the surviving one ; the second elephant is reported to have been shot a few years ago. The survivor does raid crops and is certainly in danger of being eliminated. The relation of these elephants to the others is not clear.

Discussion

The district of North Kanara with its hilly terrain, and malarious climate remained largely under forest cover and very thinly populated until the recent times. The huge forest was extremely rich in wild life, being particularly known for the gaur and tiger. This northernmost part of the elephant range was included in the British Province of Bombay presidency while the adjacent range of elephants to the South was included in the Old Mysore State. Kumri cultivation was banned in forests of the Mysore State in 1847 and that resulted in a large influx of people to the North Kanara areas (Garland 1935). Perhaps as a result, these forests are characterised by the existence of extensive enclaves of cultivation even inside the reserved forests (Plate I).

This cultivation inside the forests has been continually on the increase and has accelerated since Independence. The pace of settlement of people into this area has particularly increased since the eradication of malaria in the nineteen-fifties. The recent years have also witnessed many other disturbances in the forest, particularly with the starting of a paper industry at Dandeli and the execution of the giant Kalinadi Hydroelectric Project and mining for manganese (Plate I). As fig. 3 shows a great deal of the forest in the Haliyal division has been lost either to submersion or to mining, and the rest is more and more subject to enclaves of cultivation.

The demands of the people on the forests for firewood and grazing are also escalating. Vast areas in Sirsi and Honnavar divisions are classified as minor forests which are open for collection of leaves for manure, firewood etc. Most of these areas are completely degraded and reduced to scrub from the original semi-evergreen condition. Several thousand families of a pastoral caste called Gavli Dhanagars have migrated from the north and have settled with their buffaloes and cattle throughout the Haliyal, Yellapur, Mundgod, and other taluks of North Kanara. Overgrazing by the animals belonging to these people is seriously affecting forest regeneration.

This tremendous loss of vast chunks of forest habitat along with the degradation of the rest has seriously depleted the wild life of this area. Elephants are particularly susceptible because they wander over a vast terrain and are attracted to the cultivated enclaves inside the forest. When they indulge in extensive crop raiding they are shot at and slowly eliminated. A very large number of elephants has been killed in this fashion throughout North Kanara. There even used to be a reward for the killing of crop raiding elephants. All these pressures have well nigh eliminated the elephant from this vast tract of forest. The Dandeli Wild Life Sanctuary which could have played a role in the preservation of wild life in this area has been very heavily disturbed by the Kalinadi Hydroelectric project and there are moves to remove it from the protected areas list.

A bold and imaginative approach is called for if we are to save the relics of the magnificent wild life of this area. Perhaps a new sanctuary could be constituted around the Supa dam by incorporating areas from Nagargali, Jagalbet, Supa and Dandeli ranges. All pockets of cultivation from this sanctuary should be shifted by taking advantage of the resettlement programmes for the submersion areas. Such a sanctuary around the Supa lake could develop into a great tourist attraction, and could save at least some of the rich wild life of this area.

CRESTLINE

To the south of the North Kanara forests the crestline of the Western Ghats rises to much greater altitudes exceeding 2000 metres in places (latitude 11°30′N to 14°N, longitude 74°15′ to 76°30′E). The hill ranges here are further inland and narrower than in North Kanara. The rainfall is very high, exceeding 6000 to 7000 mm in places. It is also the place of origin of a number of important rivers like Nethravathy, Tunga and Bhadra. To the west of the crestline, there are belts of evergreen forest on the rather steep slopes. The important genera of evergreen forest include *Dipterocarpus*, *Hopea* and *Poeciloneuron* in the northern parts and *Viteria*, *Calophyllum* and *Canarium* in the southern parts. The semi-evergreen and moist deciduous forests are located mostly on the eastern slopes, while the foot hills on the western face are characterised by *Terminalia*, *Tectona* and *Lagerstroemia*.

Although the area harbours all the major wild life species including elephant, gaur, sambar, wild boar, spotted deer, wild dog, panther and tiger, the only species to be seen in sizeable numbers is the wild boar.

Elephant population

Only a few isolated groups of elephants are found in these evergreen forests. This is obviously a suboptimal habitat for elephants and there are only four small herds of elephants in this areas (see fig. 4).

Herd 1 : One or two elephants are reported from the Meginevalley, Kollurghat, Nagavalli areas (Kesava Vittal 1945). Elephants raid crops occasionally in villages in Meginevalley and Nagavalli. This area adjoins the range of Herd No. 5 of North Kanara, but a hill range

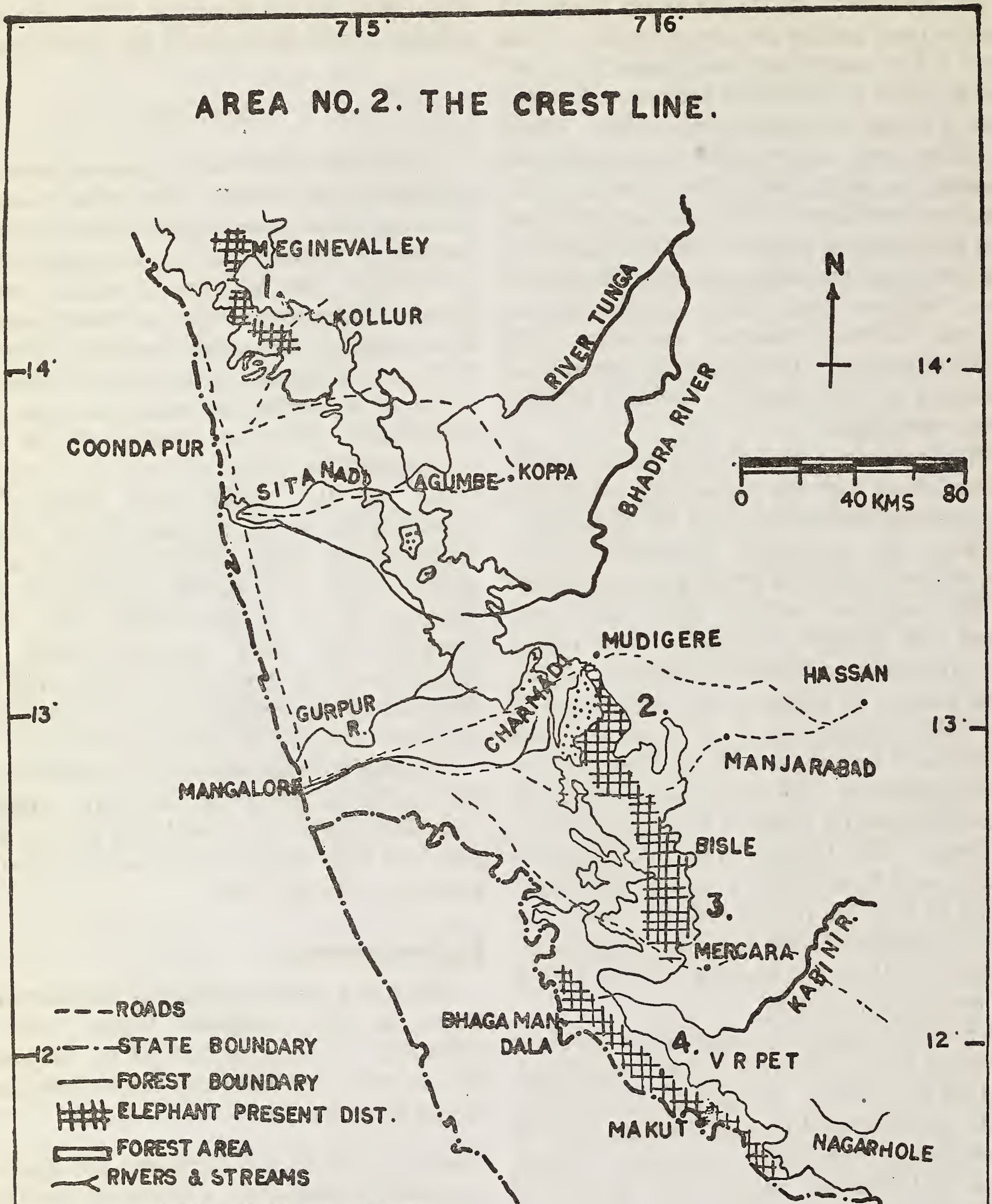

AREA NO. 2. THE CREST LINE.
75°
76°
14°
13°
12°
N
0
40 KMS
80
MEGINEVALLEY
KOLLUR
RIVER TUNGA
BHADRA RIVER
COONDAPUR
SITA NADI
AGUMBE
KOPPA
MUDIGERE
HASSAN
GURPUR R.
CHARMADI
2.
MANJARABAD
MANGALORE
BISLE
3.
MERCARA
KABINI R.
BHAGAMANDALA
4.
V R PET
MAKUT
NAGARHOLE
ROADS
STATE BOUNDARY
FOREST BOUNDARY
ELEPHANT PRESENT DIST.
FOREST AREA
RIVERS & STREAMS
CULTIVATION INSIDE FOREST

Fig. 4. Distribution of elephants along the crestline of Western Ghats.

forms a geographical barrier between them. Recent sighting indicate the presence of a single elephant only in this area.

Herd 2 : South of the area described above, a small herd of 5-6 elephants is reported in the ghat forests of Mudigere, Belthangadi and Uppinangadi ranges. These elephants cause serious damage to crops in villages like Sathyaganahally, Guthyhally, Byrapura, and Kumbharde. Repeated complaints from these villagers, situated mostly deep inside forest has forced the authorities to seek permission to shoot these elephants.

Herd 3 : Further south there is another group of elephants ranging in the ghat forests of Bisle, Shiradi, Pushpagiri, Subramanya and Sampaje. The number of elephants reported is about 15 and they raid paddy and arecanut gardens. The elephants seem to be in 2 groups, the smaller one of 5-7 elephants moving in the forests near Shiradi and the others in remaining areas.

Herd 4 : This is the southernmost herd in the western ghats proper of Karnataka. They range over extensive evergreen forest areas of Brahmagiri, Makut, Bhagamandala and some parts of Sulya forest ranges. About 20 in number, they raid crops of paddy, pineapple, jack, plantain, arecanut and tapioca.

Discussion

Even though elephants are not frequently found in evergreen forest in large numbers, their great adaptability to different climates and a very wide spectrum of food species enables them to survive in these forests. Probably they have migrated to these areas from the deciduous forests on either side of the ridge when the latter areas were brought under plough. Thus the evergreen forests which earlier were only their summer resorts for water and fodder which will be scarce in the drier forests have become their permanent habitat (Plate II).

Extensive crop raiding is indulged in by the elephants of this area and it invariably results in the killing of the pachyderms. Establishment of villages in the cultivable areas, deep inside the forest and the continued release of land in the middle of the forest has led to more and more crop raiding and the consequent killing of the elephants (Plate III).

MALNAD

The Malnad area lies to the east of the Western Ghats described above, separated from the latter by a wide belt of coffee plantations and cultivations. The area is relatively plain with an elevation of 800 to 1400 metres from sea level. The area extends from Aynur in the north to Mudigere in the south between latitudes 13°N and 14°15′N and longitudes 75°E to 76°E with an annual rainfall of 1500 mm to 800 mm. There are 3 main hill ranges, namely the Shankar hills, Karadibetta and the Bababudangiris. The rivers Tunga and Bhadra flow along this area. This region includes the Shettihally Wild Life Sanctuary and the Bhadra Wild Life Sanctuary.

The vegetation of this tract is of tropical moist deciduous and dry deciduous nature with *Tectona grandis*, *Lagerstroemia lanceolata*, *Anogeissus latifolia*, *Xylia xylocarpa* and *Terminalia tomentosa* being the characteristic species. The forest is fairly thick with an extensive undergrowth of weeds and bamboo.

This region has one of the best wildlife concentrations in the state, harbouring populations of elephants, gaur, sambar, spotted deer, wild pig etc. The Bhadra Wild Life Sanctuary is one of the few places in the state where one could easily sight gaur. The anthropogenic pressures over the area are much less and hence the rich wild life of this area has remained largely unmolested.

Elephant population

The presence of perennial rivers, reservoirs, and plenty of bamboo, grass and other fodder species in a moderate rainfall area makes this region an ideal habitat for elephants. There are five groups of elephants in this area (see fig. 5).

Herd 1 : This comprises 2 or 3 elephants, which often raid crops in different villages in the Anandapuram, Rippenpet and Aynur forest ranges. The recent killings of 2-3 people by these elephants has given them much notoriety. Human disturbance causes them to move over extensive areas, coming more and more in contact with villages and cultivation.

Herd 2 : Forests in the range of Sacrebyle had a large population of elephants before the construction of the Tunga reservoir, but harbour only about 5 elephants now. The clearing of vast areas of forest both from submersion and for rehabilitation has brought the elephants in conflict with human settlements everywhere. Because of persistent complaints of crop raiding the authorities are contemplating capturing the elephants. The elephants sometimes cross the river and destroy crops in some parts of Umblebyle range also.

Herd 3 : This is a large population of elephants, further divided into two groups most of the year by the backwaters of the Bhadra reservoir and steep hills with plantations of coffee. Construction of the Tunga reservoir has already isolated herd No. 2 from this herd. The first group, about fifteen in number stays in the forests of Lakkavally range, sometimes crossing into the forests and villages of N.R. Pura forest range doing occasional damage to crops. Some attempt was made to capture a few of these elephants but it is reported that none of the captured elephants survived in captivity.

The second group is the largest of all the herds considered so far and consists of a breeding population of about 30 to 40 elephants moving mostly in the forests of Bhadra Wild Life Sanctuary. Excepting occasional damage done to the villages deep inside the forest and one or two peripheral villages the problem of crop raiding is not severe in case of this herd.

Herd 4 : In addition to these, elephants are occasionally seen in parts of Balehonnur and deciduous forests of Mudigere and Kalsa forest ranges numbering not more than 10 in all. One of these elephants was accidentally electrocuted last year while raiding crops.

Herd 5 : The few elephants seen in the dry deciduous forests of Hassan range also may be included along with the Malnad areas.

Discussion

The dry and moist deciduous vegetation, with a number of fodder species and perennial water sources make this area an ideal habitat for elephants. Even though the area is now very much fragmented, most of the habitats are still large enough to support small populations. It is quite possible to protect elephants of herd No. 3 with some effort because the villages inside its range are few and other anthropogenic disturbances are at a minimum.

MYSORE PLATEAU

This area, between latitude 11°35′N and 12°45′N, and longitude 75°45′E and 77°E lies on the eastern side of the Western Ghats, adjoining the forests of Kerala and Tamil Nadu. The region is mostly plains, with rainfall ranging from 1000 mm to 600 mm. The vegetation is dry and moist deciduous consisting mainly of teak, *Anogeissus latifolia*, *Terminalia* and *Lagerstroemia* species and bamboos. Rivers Kabini and Cauvery flow along this area. This region includes the Bandipur National Park and Nagarhole Wild Life Sanctuary.

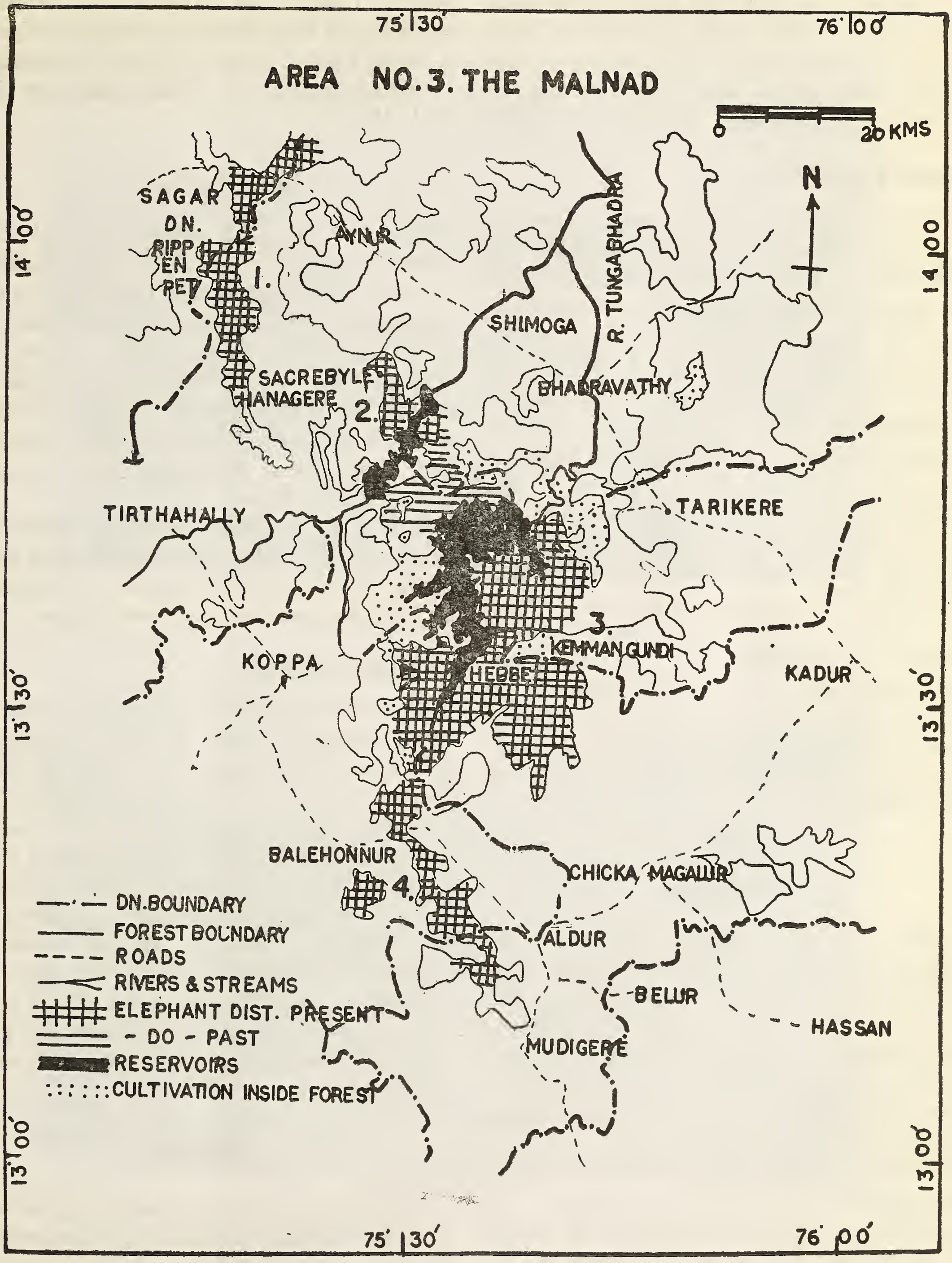

75°30'
76°00'
AREA NO. 3. THE MALNAD
0
20 KMS
N
14°00
13°30
13°00
SAGAR DN.
RIPPEN PET
AYNUR
1.
SHIMOGA
R. TUNGABHADRA
BHADRAVATHY
SACREBYLE
HANAGERE
2.
TIRTHAHALLY
TARIKERE
3.
KEMMANGUNDI
KOPPA
HEBBE
KADUR
BALEHONNUR
4.
CHICKA MAGALUR
ALDUR
BELUR
HASSAN
MUDIGERE
DN. BOUNDARY
FOREST BOUNDARY
ROADS
RIVERS & STREAMS
ELEPHANT DIST. PRESENT
- DO - PAST
RESERVOIRS
CULTIVATION INSIDE FOREST

Fig. 5. Distribution of elephants in Malnad area.

The area has perhaps the best wild life concentration in South India, harbouring large herds of elephant, spotted deer, wild pig, wild dog, hanuman langur, and in some parts gaur, sambar, and occasionally tiger and other cats.

Elephant population

About five elephants that are reported around forests of Somavarpet—in Maldare and Dubare state forests are more or less isolated from the rest of the population which has a continuous range in an extensive forest. The elephant population of this region cannot be described in herds for their ranges overlap and it is difficult to identify the individual herds (see figure 6).

There was a large concentration of elephants along the Kalkare, Begur, Bandipur and Mudumalai area during the rainy season when a survey was conducted in 1975. Migration of elephants from the wetter areas of Coorg, Wynaad and Benne during the monsoon to these drier tracts is responsible for this. The total number of elephants in the Bandipur-Mudumalai area was estimated around one thousand and that in the remaining Nagarhole areas around three hundred. There does not seem to be any notable disparity in the sex ratio (Plate IV).

Discussion

Here, too, the elephant habitat has been continuously shrinking. The destruction of Pulpally forests of Kerala is probably the reason for the high density of elephants in Gundre and Begur areas. If this trend is continued it would result in further overcrowding of the elephants. There are problems arising from crop raiding in most of the peripheral villages. There is occasional poaching of larger mammals in this area especially in the north-western parts. The construction of the Kabini reservoir has created a geographical barrier for movement of elephants. Fodder and water is not uniformly available, but if the elephants are able to migrate to wetter areas in summer, it would not become a limiting factor. For fuller details see Nair *et al.* (1977).

KOLLEGAL HILLS

This area, lying between 11°30′ and 13°N latitude and 77°15′ and 77°45′E longitude, extending from the Nilgiris to Bangalore is a Western spur of the Eastern Ghats. This discontinuous chain of hills harbours mostly dry deciduous and scrub forest. The rainfall is around 500 mm except on the high BRT hills where it is nearly 1000 mm. The dominant tree genera are *Anogeissus*, *Ficus*, *Acacia*, *Grewia* and *Santalum*.

Almost all the major wild life species like sambar, spotted deer, gaur and wild boar occur in this area only in small numbers and hence the elephant becomes the prominent species.

Elephant population

This extensive forest is continuous with the Sathyamangalam areas of Tamil Nadu and has innumerable villages all over the area. Elephant herds are frequently sighted, but an estimation of numbers is difficult because of their seasonal migration and because of the extensive range. A survey similar to that of the Mysore plateau is necessary to arrive at an approximate estimation. In any case the number of elephants at any time does not seem to exceed 200 in this area. There is frequent crop raiding in many villages and a few elephants get shot annually during this process (see figure 7).

Discussion

This area can sustain a large population of elephants because of the presence of the perennial Cauvery river, many fodder species of trees and

Above : Paddy cultivation in the middle of forest in North Kanara. Such fields are subject to severe crop raiding by elephants.

Below : Manganese mining in North Kanara ; a major source of disturbance in elephant forest.

Nair & Gadgil: Elephant population of Karnataka

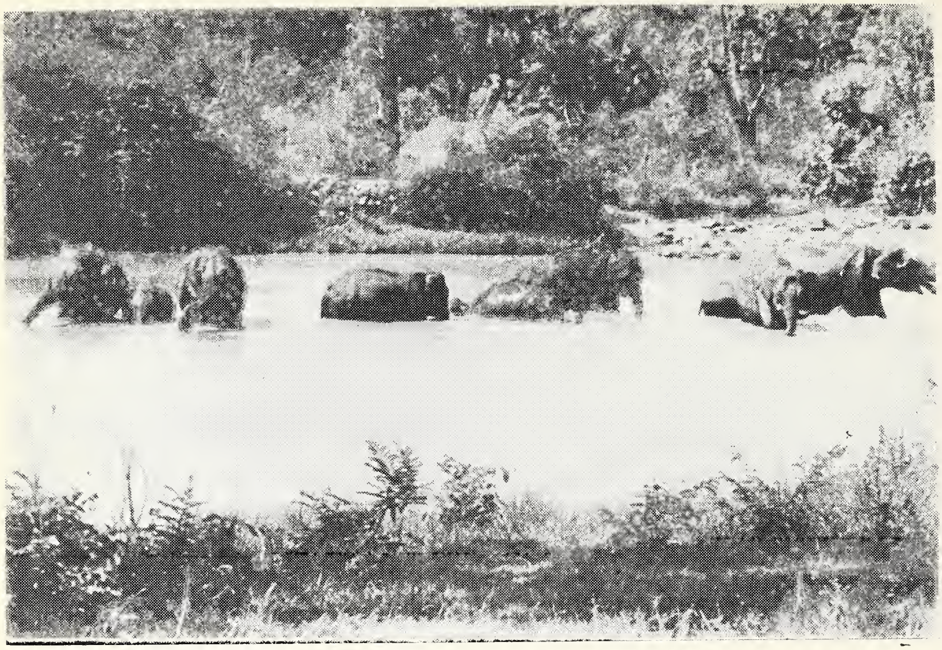
Above: The grassy downs of Western Ghats in Karnataka are not a habitat favoured by elephants.

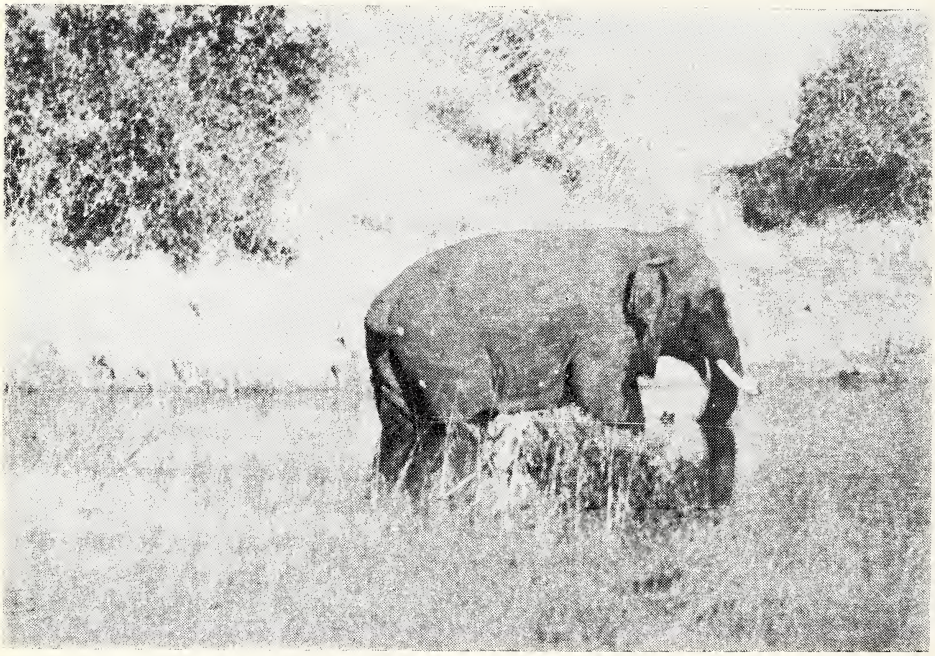
Below: Dense evergreen vegetation on Charmadi hills. This is a suboptimal habitat for elephant.

Nair & Gadgil: Elephant population of Karnataka

Above: An arecanut garden in the middle of forest in South Kanara. The trees lying on ground have been damaged by elephants.

Below: The Kerala-Karnataka border near Makut in Coorg. Hill slopes originally covered by dense evergreen forest have now been put under cultivation on Kerala side.





Above: A herd of elephants at a pond at Bandipur. This dry deciduous forest is near optimal elephant habitat during the monsoon.

Below: A stump tailed male elephant at a pond at Bandipur. Such easily identifiable animals could be followed to yield valuable data on elephant movements.

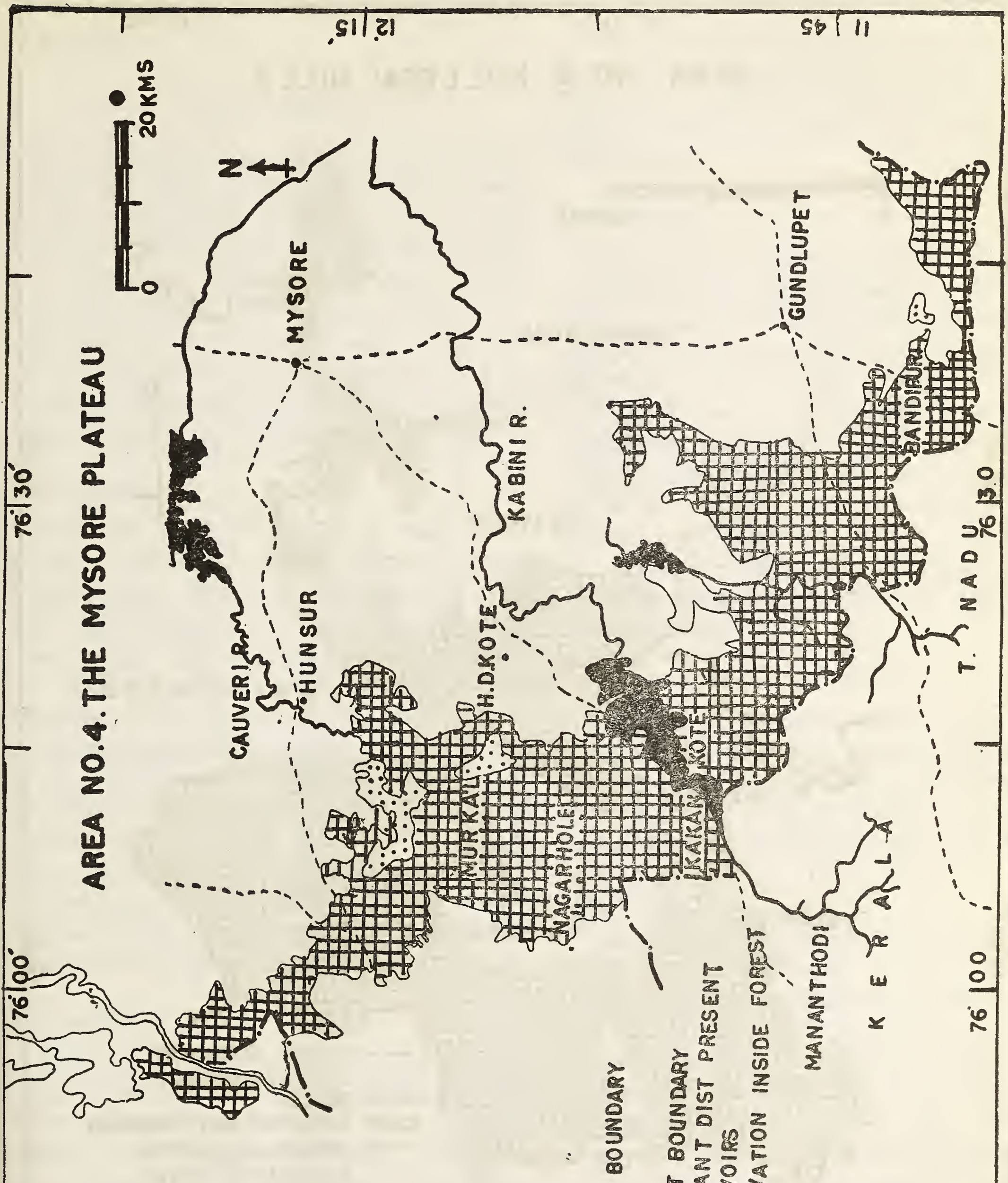

AREA NO.4. THE MYSORE PLATEAU
76°30'
76°00'
12°15'
11°45'
76°00
76°30
0
20 KMS
N
MYSORE
CAUVERI R.
HUNSUR
H.D.KOTE
KABINI R.
GUNDLUPET
BANDIPUR
MURKAL
NAGARHOLE
KAKANKOTE
MANANTHODI
KERALA
T. NADU
STATE BOUNDARY
ROADS
FOREST BOUNDARY
ELEPHANT DIST PRESENT
RESERVOIRS
CULTIVATION INSIDE FOREST

Fig. 6. Distribution of elephants on the Mysore plateau.

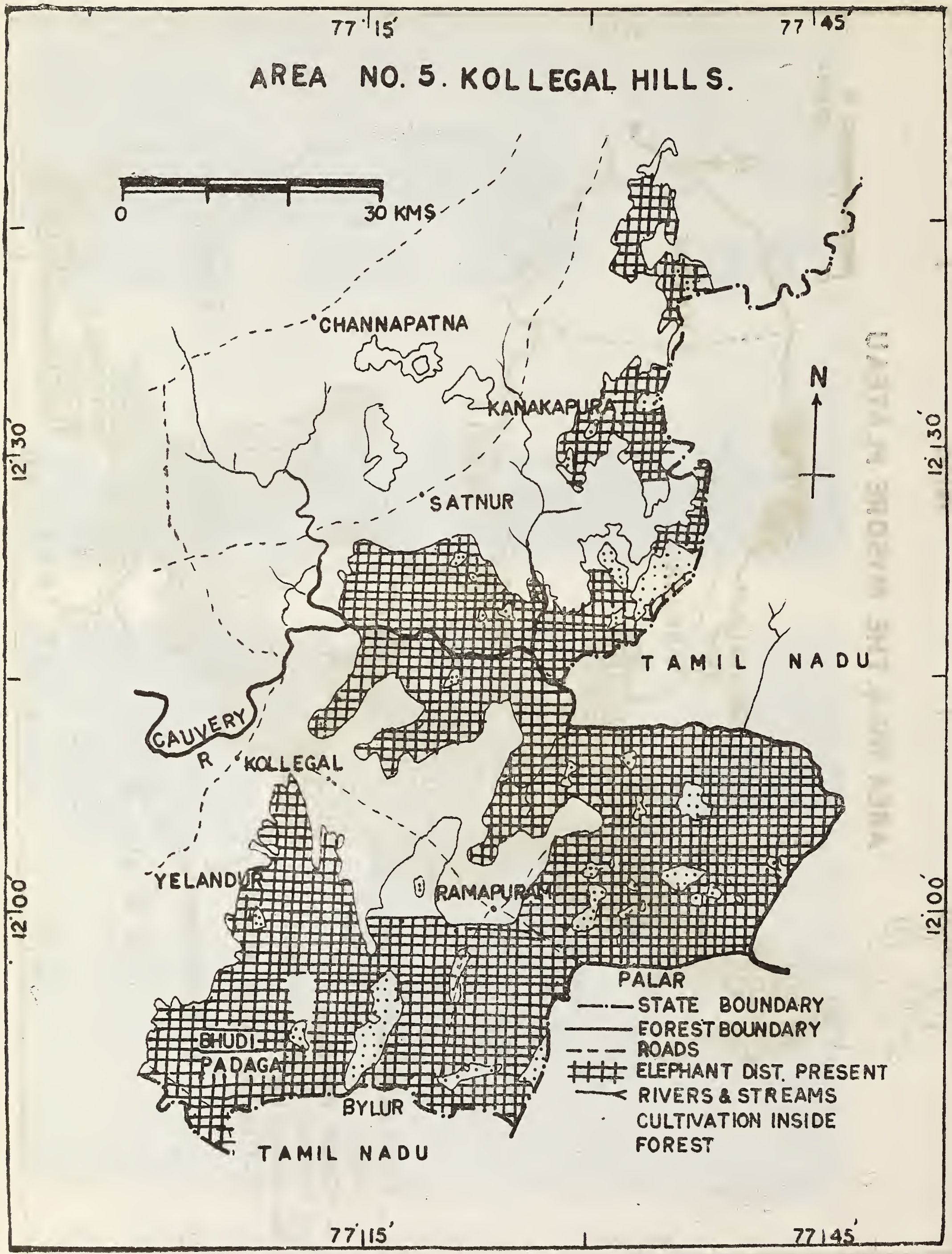

77°15'
77°45'
AREA NO. 5. KOLLEGAL HILLS.
0
30 KMS
N
12°30'
12°00'
CHANNAPATNA
KANAKAPURA
SATNUR
TAMIL NADU
CAUVERY R
KOLLEGAL
YELANDUR
RAMAPURAM
PALAR
BHUDI-PADAGA
BYLUR
TAMIL NADU
STATE BOUNDARY
FOREST BOUNDARY
ROADS
ELEPHANT DIST. PRESENT
RIVERS & STREAMS
CULTIVATION INSIDE FOREST

Fig. 7. Distribution of elephants on the Kollegal hills.

shrubs and the moist B.R. hills for migration in summer.

MANAGEMENT

It is clear that even though Karnataka has a good population of elephants their habitat is mostly discontinuous and there is an urgent need for protection of elephants and their habitat to conserve the species. Four major factors will play a crucial role in the conservation of elephants in the coming days. They are (1) overcrowding of elephant ranges, (2) construction of hydroelectric or irrigation projects, (3) crop raiding by elephants, (4) poaching.

Overcrowding :

With the rapid shrinkage of habitat, the elephants are being forced into smaller and smaller areas. Such areas consequently reach very high densities of elephant populations. The Bandipur National Park areas, for example, now harbour almost 2 elephants per square kilometre. Investigations on the African elephant suggest that elephants are at an equilibrium with their environment at much lower densities of about 1 elephant per 5 square kilometres (Fowler & Smith 1973). It is therefore likely that the densities such as currently noticed at Bandipur National Park may have serious adverse consequences in the long range. The situation obviously needs to be watched carefully.

Big projects :

The big projects consume vast areas of forest. For rehabilitating the displaced people from submersion areas further forest areas are cleared. The Tunga and Bhadra Reservoirs have divided a good population of elephants into three or four fragments. The construction of the Kali hydroelectric project will have its effects on the surviving elephants of herd No. 1 of North Kanara. The Kabini reservoir has rendered migration of elephants from Nagerhole areas to Bandipur extremely difficult. A hopeful sign, however, has been the timely intervention in construction of a reservoir near Mudumalai which has saved some of the best elephant country in South India from going under water.

Crop raiding :

Crop raiding and subsequent shooting forms the major threat to the elephants on the Western Ghats. This is the result of indiscriminate allotment of wetter areas deep inside forest and cultivation of the revenue forests or grazing lands which used to form a buffer between wild animals and cultivation. Almost all the herds of elephants in Karnataka raid crops today and to protect both the crops and elephants is difficult. Rehabilitation of some of the villages out of places with a good concentration of elephants seems imperative if the elephant is to be protected.

Poaching :

Poaching of elephants, though rare in the areas under study, does occur in some parts especially on the eastern side of Kollegal hills. This if extensive could disturb the sex ratio and have a very adverse effect on the populations.

The future :

Taking all factors into account, the fate of the isolated small herds of North Kanara, Crestline and Malnad areas seems sealed. There seems to be little hope of saving them, and they appear destined to be shot out one by one and disappear, as many other herds have over the past half century in these areas. There is much more hope of conserving the population of the Bhadra sanctuary area, of Nagarhole and Bandipur sanctuaries and possibly of the Kollegal hills. Even here the future depends of preventing further shrinkage of areas and encroachment by cultivation in the heart of elephant forest. Even though everything is done for the maintenance of the integrity of the habitat, a certain amount of crop raiding will inevitably continue. An effective scheme for granting compensation for loss of crops will therefore have to play an important role in the future conservation of elephants of Karnataka.

ACKNOWLEDGEMENTS

We are grateful to the authorities of Karnataka State Forest Department without whose generous co-operation this survey would not have been possible. We were greatly encouraged in this work by World Wildlife Fund, India, by the West Coast Paper Mills, the Southern Indian Task Force on Elephants, and the Asian Elephant Group of the Survival Services Commission of the International Union for the Conservation of Nature and Natural Resources. We are also grateful to our colleagues at the Indian Institute of Science for help in the field and for stimulating discussions.

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THE STATUS, ECOLOGY AND BEHAVIOUR OF LION-TAILED MACAQUE (*MACACA SILENUS*)

J. MANGALRAJ JOHNSON[1]

(*With three plates*)

INTRODUCTION

In part fulfilment of a postgraduate Wildlife Management course a dissertation work was to be undertaken on a wildlife problem. It was then suggested that I may work as a colloborator with Dr. Steven Green when his research proposal on the Lion-tailed Macaque was being evaluated. My dissertation on Status, Ecology and Behaviour of Lion-tailed Macaque was accepted by the faculty of the Wildlife management course, Forest Research Institute and Colleges, Dehra Dun. The field work lasted for 28 days: 8 days during November 1973, 17 days in December 1973, and 3 days in January 1974. General observations amounting to many more days were made before and after this intensive study period. Also a brief study was made on captive specimens in the Delhi Zoo for about 2 weeks. (see Table IX.)

The Nilgiri Langur *Presbytis johni* is persecuted for its blood and flesh, believed to be a cure for asthma. The species has almost been exterminated in localities where they were once common. Similar property is supposed to be possessed by the Lion-tailed Macaque *Macaca silenus* also. Unlike the Nilgiri Langur which is very fast moving and which disappears at the sight of human beings, the Lion-tailed Macaque is slow moving and can be easily shot. The whitish grey ruff around its face clearly reveals its movements even in its shady and darkened habitat.

As these monkeys consume a varied vegetation, people believe that they choose, select and eat only medicinal herbs and hence their blood and flesh are a panacea; '*Karunkurangu Rasayanam*' is a recognised preparation of the Ayurvedic system of medicine. In Sanskrit and Ayurvedic literature no distinction is made between the Nilgiri langur and the Lion-tailed Macaque. This study is an attempt to estimate the existing population in Tamil Nadu and to understand their food and ecological requirement to enable effective management in future.

STUDY AREA

For the intensive field study, a part of Manjolai Estate where Green had been working on vocalization etc. of the Lion-tailed Macaque was chosen. The Bombay-Burma Trading Corporation had taken the major portion of the Shola Forests of Singampatti Forest (of Tirunelveli South Division) for Tea, Coffee and Cardamom Plantations.

The study area (8° 33.5′N, 77° 23′E, 1300 m. above M.S.L.) is situated close to Manimuthar river and consists of Evergreen Forests (Sholas), Cardamom Fields, abandoned Coffee Plantations with secondary growth and Red Gum (*Eucalyptus tereticornis*) plantations. There are trails, within the cardamom fields maintained by the Estate and within the Forests made and maintained by Dr. Green. The temporary log bridges got washed away thrice during the period of study.

During the study the Lion-tailed Macaque was found in the following associations of the

---

[1] Wild Life Warden, Mundanthurai Sanctuary, Shencottah-627 809, Tamil Nadu.

West-Coast Tropical Evergreen Forest (Champion and Seth FOREST TYPES OF INDIA 1968). (see Table I.)

The *Cullenia-Palaquium* Association is the most widespread, growing on deep well drained soil occurring at 750 m to 1050 m. Sometimes they occur in patches exhibiting the denser state towards gregarious. This is the most favoured and almost exclusive habitat of Lion-tailed Macaque.

T. V. Iyer (*Indian Forester*, August 1932) Volume LVIII (8) found the following tree density per acre.

Mesua ferrea	3.73
Palaquium ellipticum	5.45
Calophyllum elatum	0.88
Artocarpus intergrifolia	0.44
Dysoxylum malabaricum	0.07
Toona ciliata	0.03
Bischofia javanica	0.09
Acrocarpus fraxinifolius	0.08
Hopea glabra	0.49
Eugenia sp., *Syzygium* sp.	0.11

The Lion-tailed Macaque is endemic to this region alongwith :

1. The Nilgiri Langur *Presbytis johni* (Fischer).
2. The Nilgiri Brown Mongoose *Herpestes fuscus* Waterhouse
3. The Malabar Civet *Viverra megaspila civettina* Blyth

The avifauna seen in the macaque habitat is given in the table II.

TABLE I

Association	Altitude	Soil	Rainfall	Status
Filicium-Alsoeodaphne	250-600 m	shallow, laterite	2500 mm	edaphic climax
Hopea-Mesua	300-500 m	moderately moist	3000 mm	low elevation climax
Palaquium-Mangifera	650-800 m	clayey, slowly drained	4000 mm	medium elevation climax
Gluta-Palaquium	..	moister	..	edaphic climax
Cullenia-Palaquium	800-1100 m	deep, well drained	5000 m	medium elevation climax
Palaquium-Mesua	1000-1200 m	moist	4000 m	medium elevation
Cullenia-Calophyllum	over 1100 m	wet	3000 m	post climax
Poeciloneuron	1000-1200 mm	damp		optimum
Cullenia	(Ghat crests)		5000 m	moisture climax

TABLE II

No.	Common Name	Scientific name	No. of times seen or heard	
			In Manjolai	In other places
1.	Laughing Thrush	*Garrulax jerdoni*	7	8
2.	Mountain Thrush	*Zoothera dauma*	3	4
3.	Large Woodshrike	*Tephrodornis virgatus*	—	5
4.	Fairy Blue Bird	*Irena puella*	54	18
5.	Yellowbacked Sunbird	*Aethopyga siparaja*	—	5
6.	Spiderhunter	*Arachnothera longirostris*	—	3
7.	Malabar Golden-backed Woodpecker	*Dinopium javanense*	9	7
8.	Heartspotted Woodpecker	*Hemicircus canente*	3	2
9.	Malabar Great Black Woodpecker	*Dryocopus javensis*	9	27
10.	Nilgiri Speckled Piculet	*Picumnus innominatus*	6	3
11.	Bluebearded Bee-eater	*Nyctyornis athertoni*	—	1

The following are the Rainfall, Temperature and Humidity particulars from records of Manjolai Estate and collected during the study.

The annual rainfall during 1972 and 1973 in the study area was 2982 mm and 3440 mm respectively. The average rainfall for different months in a year is given in the table III.

For this study the following categories of Forests were recognised :

Category		Area
1. Primary Forest	832 ha.	3.21 sq. miles
2. Cardamom Fields	896 ha.	3.46 sq. miles
3. Coffee and Red Gum Fields	512 ha.	2.98 sq. miles
Total ..	2240 ha.	9.65 sq. miles

TABLE III

November 1973	Rainfall	Temperature °C
23	..	Min. 57 — Max. 74
24	6 mm	„ 56 — „ 72
25	23 mm	„ 55 — „ 69
26	8 mm	„ 58 — „ 64
27	..	„ 56 — „ 70
28	19 mm	„ 57 — „ 70
29	14 mm	„ 56 — „ 64
30	1 mm	„ 58 — „ 68
December 1973		
1	..	Min. 58 — Max. 70
2	22 mm	„ 56 — „ 74
3	27 mm	„ 58 — „ 70
4	..	„ 58 — „ 64
5	..	„ 56 — „ 74
6	..	„ 56 — „ 72
7	..	„ 54 — „ 76
8	2 mm	„ 57 — „ 72
9	..	„ 54 — „ 70
10	..	„ 52 — „ 72
11	..	„ 54 — „ 72
12	12 mm	„ 54 — „ 72
13	39 mm	„ 56 — „ 60
14	1 mm	„ 58 — „ 64
15	20 mm	„ 60 — „ 70
16	78 mm	„ 61 „ 70
17	141 mm	„ 58 — „ 69
January 1974		
13	..	„ 52 — „ 74
14	..	„ 52 — „ 76
15	..	„ 52 — „ 78

Sightings of the Lion-tailed Macaque :

Five troops were seen in the area during the period of study. They were identified and recognised by individuals with conspicuous marks. (Table IV.)

AGE CLASSES

The age classes recognised for study in the field is given in Table V.

PRESENT DISTRIBUTION OF THE SPECIES

Extensive correspondence with Forest Officers, Game Associations, Sportsmen and Estate Managers was undertaken and a questionnaire was circulated to know the present distribution of the Lion-tailed Macaque and to estimate their population. All available literature, chiefly the Journal of Bombay Natural History Society was consulted. The following are the localities where the existence has been confirmed.

1. Panniar Estate—Kerala.
2. Marakkadu.
3. Cardamom Hills.
4. Shencottah Forests.
5. Courtallam Water Falls.
6. Vellodai Valley.
7. Cumbum Valley.
8. Nelliampatti Hills.
9. Highwavy Mountain.
10. Periyar Sanctuary.
11. Anamalai Hills.
12. Nilgiri-Wynaad.
13. North-west face of Nilgiris.
14. Saklesphur Area.
15. Area between Kudremukh and Bhagavathy.
16. Agumbe.
17. Anshi Ghat.
18. Ramgiri.

ACTIVITIES

Activity was observed in the field and in captive specimens. I did a brief study of the Lion-tailed Macaques kept in a paddock in the Delhi Zoological Park during the period between 16-8-1973 and 28-8-1973 and took notes on their activities. For the study at the Zoo, I categorized the activities as :

1. Feeding ;
2. Moving ;
3. Playing ;
4. Resting and sleeping.

Though sexual activities were observed, the participants and duration were comparatively few and they are included in playing.

Any activity lasting more than 5 seconds was recorded. In the Zoo, notes on activities were taken for 10 minutes (5.55-6.05 : 6.55-7.05 etc.). While in the wild whenever observations on activities were made, they were recorded continuously.

In the Zoo, they spent more time playing and less on feeding. But in the wild it was the opposite. But duration of movement was same under both conditions. Play activity was noted in the Zoo throughout the day, while in the wild it was found to be restricted to certain hours of the day.

PATHWAYS

Though these macaques appear to move haphazardly regular pathways in trees are followed by different troops.

In these pathways, there were normally no dead or dry branches.

I could not observe any specific order of movement of troop members. Usually females moved first, while juveniles and subadults followed. Males, though always close to the route, moved about rather erratically.

TABLE IV

Troop	Mark on identifiable Member	Composition
LIEF	Male with Females Nip (Long Nipple) and Stump (Stumpy tail)	1 Male (Lief) 4 Females (Nip & Stump) 3 Sub-Adult Females with infant
NOSE	Male with a torn Nose	1 Adult Male (Nose) 3 Females 1 Sub-Adult Male & 2 Sub-Adult Females 3 Juveniles
WART	Male with a wart on his face	1 Adult Male (Wart) 5 Females 1 Sub-Adult Male
KINKS	Female with a kink in its tail	1 Adult Female (Kink) (about 25 animals)
HAND	Male with a swollen left hand	1 Adult Male (Hand) 3 Adult Females, 2 Sub-Adult Males, 3 Sub-Adult Females

Age class categorising of Kink's troop was not possible.

TABLE V

Class	Age	Field identifications	Remarks
Infant	0-6 months	Fleshy Face, No whiskers clinging to mother	
Juvenile (Sub-Juvenile)	6-18 months	By comparative size, coat colour, attachment to Adult Female	
Juvenile	18-30 months		This differentation was not made in my study in Manjolai
Adolescent Female	30-42 months	Among adolescents males are identified by presence of testicles	
Adolescent Male	30-54 months		
Sub-Adult Female	42-54 months	By comparative size and behaviour	
Sub-Adult Male	54-90 months	Male identified by grey hair on the testicles	Colour of fur of inside of thighs changes
Adult Female	54 months and above	By comparative size and behaviour	
Adult Male	90 months and above	Male identified by well developed facial ruff and by testicles	

FOOD AND FEEDING BEHAVIOUR

Food :

Leaves and leaf buds from trees were generally eaten. They also eat the bark of some trees, tree moss, leaf galls, grasshoppers and other insects and lizards ; unidentified egg shells were found in their excreta. The species of trees and parts eaten are given in table VI.

Feeding Behaviour :

Feeding starts immediately after waking and is continued on the nearest tree where food is available and till they sleep. There was no competition between individuals for food ; while feeding, the sub-adults moved away at the approach of leader males.

Leaves and fruits were stripped off branches and eaten and on some occasions (5 observations) they bent the branches towards their mouth and ate.

Barks were stripped off dead branches to look for grub and adult insects. If found and caught, these are examined and then eaten alive.

Lizards were chased and caught. A leader male (Nose) tapped the bottom of a branch with his left hand, when a disturbed lizard ran up the branch, he caught it by his right hand and put into his mouth. No part of the lizard was thrown out. Grasshoppers were searched for on the ground by carefully turning up grass blades. The Shikra *Accipiter badius* followed the macaques troops on many occasions ; when macaques moved about on the branches some lizards get disturbed and moved on the branches. These were readily caught by the shikra (5 observations).

Cullenia excelsa :

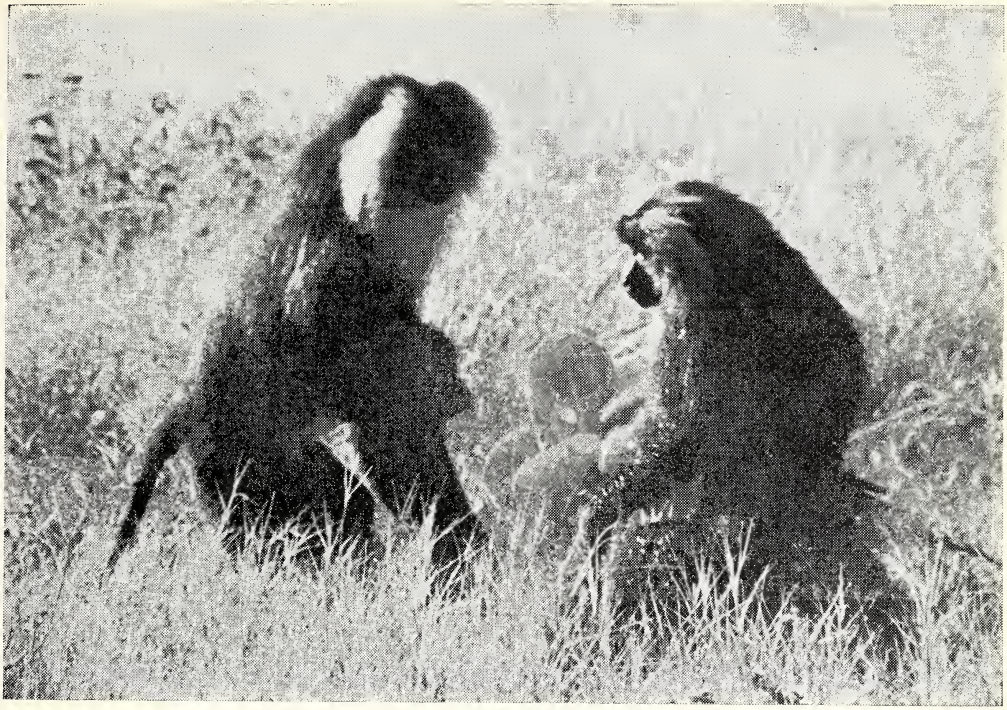
As the local name *Kurangupila* (Monkey Jack tree) for *Cullenia* indicates, this fruit is the macaques' favourite diet.

Leaves, buds, flowers and fruits of *Cullenia excelsa* formed their major food during the period of my study. This evergreen tree is also endemic to the Western Ghats and its distribution is almost the same as that of *Macaca silenus* in India. *Cullenia excelsa* is also found in the central districts of Sri Lanka where this macaque does not occur.

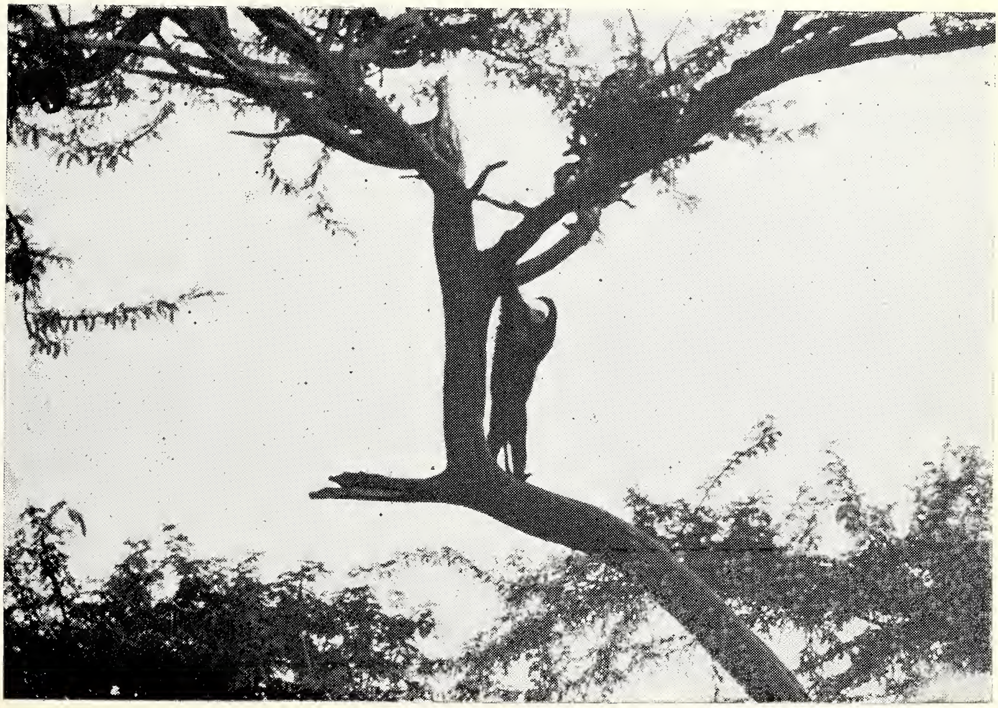
Its English name is Wild Durian and the local names are : Tamil—*Malai-kongi, Aini-pillae, Vedipala,* Singhalese—*Katu-boda, Kabodda, Karani,* Travancore Hills—*Kar-avani* and Malayalam—*Mullen-chakka, Mullanchakka, Vedipilavu, Karayani.*

TABLE VI

Tree species	Part Eaten				
	Bark	Leaf buds	Leaf	Fruit	Leafgalls
Cullenia excelsa ..		×	×	×	
Eugenia spp. ..	×		×		×
Ternstroemia sp. ..	×		×		×
Artocarpus sp. ..			×	×	
Elaeocarpus sp. ..			×	×	
Myristica sp. ..			×	×	
Cinnamomum sp. ..			×		
Coffea arabica ..				×	



Adult female with infant.



Macaque descending.

Sleeping clusters.

Female in oestrous.

The oestrous female presenting to male

Allogrooming.

The tree is a native of the Tropical Wet Evergreen Forests of the Deccan Peninsula and is found in the Western Tropical Evergreen type (Champion's classification 1AC3). Though it is an evergreen tree, there is a perceptible fall of old leaves during the dry, hot season of March, which is accompanied almost at the same time by a flush of new leaves. Another, though less perceptible, flush of new leaves appears after the cessation of the summer monsoon in October-November, especially in localities where South-West monsoon brings the bulk of the annual rainfall. The flowers appear during the hot season, about February-March, and the fruits ripen during the rainy season.

Feeding on the Cullenia fruits :

The fruits were twisted off or occasionally bitten off the stalk. The thorny exterior of the fruit does not appear to hurt the animals, because they tug, carry and carve out bits easily. They also ate the fruits, without removing them from the branch, if the situation was suitable.

They often examine and let go the fruits after partially detaching them from the branches, half-twisted probably to verify the stage of ripeness. In the process, many fruits fell down—sometimes narrowly missing the head of the observer below !

After removal of the fruits (15-20 seconds) they turned and split off bits of the thorny exocarp (10-25 seconds) ; sometimes take fruit to a suitable location for eating.

The seeds are taken out with the fingers and either kept in the facial pouch or eaten. The split testa invariably falls slowly down. In no fruit were all the seeds eaten and half-eaten fruits are often thrown away and another fruit removed.

Sleeping Clusters

A single troop was usually followed and observed until dusk when they went to sleep. The roosting site was marked and the next morning, before the animals got up, the place was reached and observation resumed. The following observations were made.

1. The juveniles normally continued playing till late in the evening, while the adults settled down earlier.
2. The juveniles and sub-adults stayed huddled together while sleeping.
3. They sat facing different directions.
4. They settled mostly on the slender ends of branches (except on 2 occasions).
5. After settling down, the contents of the facial pouch were taken out and eaten and considerable quantity of testa of the seeds, was found below in the morning.
6. During the study period all the sleeping clusters were found within Cardamom forests adjoining Primary forests. None was found in the Secondary forests.
7. The clusters are small compared to the troop size. A troop normally settled for the night dividing into 2-3 clusters. (Table VII.)

Mating Behaviour :

The female in oestrous is conspicuous by her swollen hind parts and root of the tail and she often stood presenting her rear to the male.

The male mounted the female placing his hind feet firmly on the hock or holding the fetlock in between his first toe and other four toes. If the supporting branches were not firm, the female moved forward and backward, until she reached a good hold.

When mounting took place on larger branches, the male stood bipedal behind the female. The male generally held the hip of

TABLE VII

COMPOSITION OF SLEEPING CLUSTERS

Date	Composition	Whether found on the next morning
2.12.73	Adult Male, Adult Female+	Yes
11.12.73	3 Adult Female, 3 Sub-Adult Female	Yes
29.11.73	Adult Female, 2 Sub-Adult Male	No
3.12.73	Adult Male, 2 Adult Female+	Yes
7.12.73	Adult Male, 2 Adult Female, Sub-Adult Female	Yes
5.12.73	Adult Male, Adult Female with Infant	Yes
9.12.73	2 Adult Female, Sub-Adult Male, 3 Sub-Adult Female	Yes
14.12.73	1 Adult Female with Infant, 2 Adult Female	Yes
4.12.73	1 Adult Male, 1 Adult Female with Infant+	No
27.11.73	1 Adult Male, 2 Adult Female	Yes
28.11.73	Adult Male, Adult Female with Infant+	Yes
15.12.73	2 Adult Female, 1 Sub-Adult Female	No

the female with his forelimbs and thrusted (7-29 times) : just before dismounting the male gave vigorous thrusts. The female responded to the thrusts by slow semi-circular movements of her hind quarters. The female moved away sometimes, thwarting intromission.

During the period of observation 3 females were in oestrous on different days and were continually mated by the leader male. Due to the great height occupied by them, and fast movement of the troop, uninterrupted observation and clear photography were not always possible. The following are different situations of mating observed.

1. Male grabbed the tail of female, which was moving, standing or eating *Cullenia excelsa* fruits, pulled towards him and mounted lifting the tail (27 observations).
2. The male aggressively grinned, which was responded by the female, who came presenting her hind (7 observations).
3. Male mounted keeping a half-eaten *Cullenia excelsa* fruits in his mouth. After dismounting, he continued his eating (one observation).
4. The female held *Cullenia excelsa* seeds in her facial pouch during copulation ; when male dismounted, the female took out seeds and after eating dropped the testa of about 3-4 seeds (4 observations).

5. During the thrusting of male, the female squeaked, (3-9 times) retracting full lips (11 observations) and turning her face towards the partner.

6. Oestrous female followed the male (15-200 seconds): when the male stopped, the female moved past the male; who held the female and mounted (4 observations).

7. When the male caught the oestrous female by tail, she scampered away, 3 metres; after 10 seconds returned to the male, who mounted (one observation).

8. Female, after dismounting by the male came close to him and remained huddled for 10-35 seconds (9 observations).

9. Male, when female presented her behind, smelt, inspected her rear and groomed, without mounting (18 observations).

10. When oestrous female was sitting the male approached and stroked with the back of his hand; the female responded by presenting her back quadru_ pedal (11 observations).

11. A sub-adult male mounted the oestrous female; when the leader male approached 9 metres away, he moved away (one observation).

12. Though actual intromission could not be seen, ejaculate could be seen on the genitals of the male.

13. The normal sitting positions were different from the sitting positions during the mating phase. When the oestrous female was nearby the male sits exhibiting his genitals.

Vocalization :

The calls of the lion-tailed macaque have fascinated naturalists because one of its calls ‘coo’ is similar to the call made by the tribals in the jungle to keep contact with each others, as they move about collecting honey, roots etc. (Table VIII).

1. The call ‘coo’ and ‘krubb’ were made by all age classes, in all habitats.

2. The ‘squeak’ call was made by the adult female only during copulation. And often the ‘squeaks’ led to locating the mating monkeys. The Bonnet Macaques (adult females) also produce squeaks, while mating.

3. The ‘squeal’ and ‘scream’ are the calls of juveniles, in response to loneliness, aggressive behaviour by adults or sub-adults or when they were not able to negotiate their movements between branches.

TABLE VIII

FREQUENCY OF CALLS MADE BY MEMBERS IN DIFFERENT HABITATS

	Primary Forests						Cardamom Areas						Coffee, Red Gum & Secondary Forests						
Calls	Adult		Sub-Adult		Juveniles	Infants	Adult		Sub-Adult		Juveniles	Infants	Adult		Sub-Adult		Juveniles	Infants	Total
	Male	Female	Male	Female			Male	Female	Male	Female			Male	Female	Male	Female			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
'COO' ..	6	8	3	—	2	—	16	12	6	2	4	—	2	2	6	—	6	—	75
'KRUBB' ..	9	12	5	3	3	—	20	18	10	4	6	—	2	3	8	2	4	4	113
'SQUEAK'	—	25	—	—	—	—	—	52	—	—	—	—	—	—	—	—	—	—	77
'SQUEAL'	—	—	—	—	—	—	—	—	—	—	15	—	—	—	—	—	—	—	21
'SCRAEM'	—	—	—	—	9	—	—	—	—	—	14	—	—	—	—	—	—	—	23

Besides the above, 27 calls were heard in Primary Forests and Secondary Forests, these are not included here, as the callers were not seen.

TABLE IX

TOTAL ANIMAL HOURS 50 : 70

Active Participant	Passive Participant						
	Leader Male	Oestrous Female	Non-Oestrous Female	Sub-Adult Male	Sub-Adult Female	Juvenile	Infant
Leader Male ..	—	6	1	—	2	—	—
Oestrous Female ..	7	—	3	1	—	—	—
Non-Oestrous Female ..	4	1	6	1	3	4	9
Sub-Adult Male ..	5	1	1	4	6	2	3
Sub-Adult Female ..	—	—	4	6	1	1	7
Juvenile ..	—	—	—	—	6	3	1
Infant ..	—	—	—	—	—	—	—

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A COMPARATIVE ACCOUNT OF THE AVIFAUNA OF THE SHOLAS AND THE NEIGHBOURING PLANTATIONS IN THE NILGIRIS

MOHAMMAD ALI REZA KHAN[1]

(*With a plate*)

INTRODUCTION

The original evergreen forests including the sholas of the Nilgiris are disappearing fast with the raising of tea, coffee, eucalyptus and acacia plantations on the one hand and urbanization on the other. The planting of tea started a century ago, whereas eucalyptus, acacia and others came about half a century later. Nobody knows how the avifauna of this region is being affected by this fast rate of replacement of the original vegetation. The only information available on the avifauna of plantations is that of Gray (1974). His observations deal with two isolated eucalyptus plantations in Maharashtra. It is felt that soon only some small bits of evergreen forests may survive and therefore this seems the right time to record the differences between the avifauna of natural vegetation and plantations. Emphasis has also been laid on the adaptations of several species of birds resident in the plantations other than their natural habitat.

METHODS AND MATERIALS

I spent about two years (1974-76) in the Nilgiris of Tamil Nadu and some other parts of the Western Ghats in Karnataka and Kerala to study the Black-and-Orange Flycatcher *Muscicapa nigrorufa*. For about 16 months my study was concentrated at three stations namely, Coonoor (*c*. 1750 m above msl), Kotagiri (1800 m) and Ootacamund (or Ooty 2200 m) all in the Nilgiris. I had six study plots. Of these, the Government Botanical Garden (Ooty) and Sims' Park (Coonoor) were devoid of natural vegetation. Others were represented by thinned out sholas all encircled by tea, acacia and eucalyptus plantations as well as residential buildings. These provided opportunities for studying the birds of the sholas as well as of the plantations. During each visit to the study plots as well as other areas I kept regular notes on the sightings of the different species of birds and their habits. This paper is mainly based on 120 hours of observation.

A brief description of the plantations of the Nilgiris followed by comparison of the birds of the plantations and natural vegetation has been made, and an attempt to show the adaptiveness of the birds of plantations and the impact of the latter on the avifauna. A bird was considered to be a resident in the plantations when it was found nesting in the area. A pair of 10 × 50 binoculars and a 35 mm camera with a 200 mm zoom lens were used. No birds were trapped for this purpose as field identification was sufficient.

The common and scientific names of the birds have been used here from Ripley (1961),

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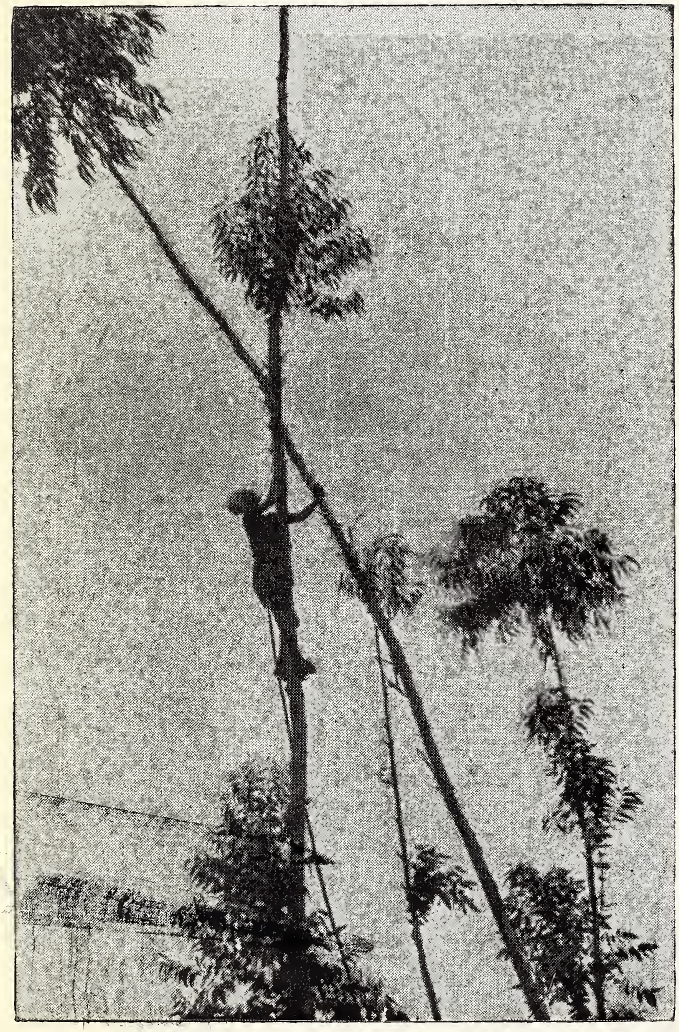

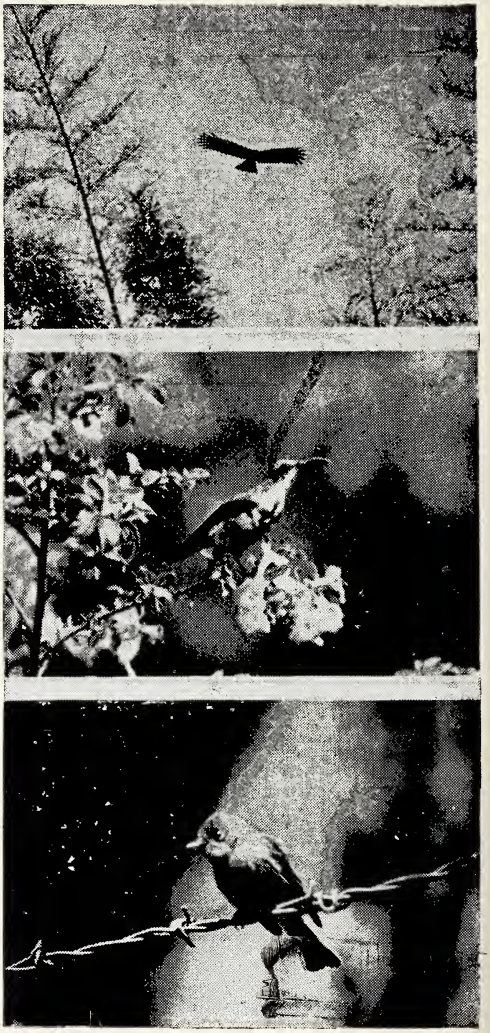

Left: Lopping of *Eucalyptus* trees—Coonoor.

Right: ABOVE: Black Eagle above a bamboo clump—Nilgiri; MIDDLE: Purple Sunbird (in eclipse plumage) on a *Streptocaulon* bush—Kotagiri; BELOW: Greyheaded Flycatcher may be seen anywhere—Ooty Botanical Garden. (Photos: *Author*)

Ali (1969) and Ali & Ripley (1968-74). The generic names of the flowering plants being adopted from Santapau and Henry (1973), and others mostly from Champion & Seth (1968).

Description of the vegetation :

Sholas : These are small pockets of evergreen forest growing on the ravine slopes or sheltered folds of the hills of the Western Ghats, usually above 1200 m msl and are termed as Southern Montane Wet Temperate Forest (Champion and Seth 1968). In the Nilgiris sholas are commonly found between 1500 and 2500 m msl. Shola trees below 2000 m rarely exceed 15 metres in height, whereas those growing above this elevation hardly ever reach 10 metres. Dominant plants include *Syzygium* spp., *Elaeocarpus* spp., *Ilex* spp., *Vaccinium* spp., *Gordonia obtusa*, *Ternstroemia gymnanthera*, *Michelia nilagirica*, *Rhododendron nilagiricum*, *Meliosma* spp., *Litsea* spp. *Photinia* spp., *Glochidion* spp., *Turpinia nepaulensis*, *Eurya japonica*, *Mahonia leschenaultii* etc. with a luxuriant undergrowth of *Psychotria*, *Oldenlandia*, *Lasianthus*, *Chomelia*, *Strobilanthus*, *Rubus*, *Smilax*, *Passiflora*, *Ipomoea*, *Bambusa nana*, *Polygonum*, *Argyreia* etc.

Tea : Tea is cultivated in *c* 25,000 hectares between 1000 and 2200 m elevation. Silver Oak *Grevillea robusta* is used extensively as shade trees. All old plantations have retained thinned out sholas along the perennial sources of water whereas the new plantations have dropped this practice totally. In small pockets within the tea plantations eucalyptus and acacia are grown for the supply of firewood. Once planted, the tea plants yield for *c*. 60 years at a stretch while shade trees are freshly planted about four times during this period. Sholas have been clear felled for planting tea. In Gudalur taluk tea is usually grown around 1000 m above msl after clear-felling evergreen forest. Birds found in such low elevation tea have not been included here.

Eucalyptus : About 15 species of *Eucalyptus* are planted of which *E. globulus* and *E. grandis* are widely cultivated for commercial extraction. These are grown usually above 1200 m and below 2500 m. Eucalyptus are either planted on grassy downs or in the folds of the hills after removing the sholas although both the grasslands and the sholas are considered to be climax vegetations for the Nilgiris (see Ranganathan 1938—Working Plan of the Nilgiris Forest Division 1969). Eucalyptus trees grow between 15 and 20 m high with very little branching. Branches and leaves are removed seasonally for oil extraction (Plate). The trees are allowed to grow for 10 years or so and there is sufficient light for the undergrowth. These two factors contribute to the healthy growth of shrubs and herbs. This undergrowth lasts for the same number of years. From the avifaunal point of view this is the core zone which ultimately provides food, shelter and breeding places. Dominant plants of such an undergrowth usually include *Solanum auriculatum*, *S. robustum*, *S. sisymbriifolium*, *S. indicum*, *Rubus ellipticus*, *R. racemosus*, *Rhodomyrtus tomentosa*, *Lantana camara*, *Maesa perrottetiana*, *Toddalia asiatica*, *Smilax* spp., *Alsophila latebrosa*, *Gleichenia*, *Carex* spp., *Passiflora*, *Polygonum*, *Ipomoea*, *Argyreia hirsuta* etc.

Acacia : Although some five species of *Acacia* are planted, *A. dealbata* and *A. decurrens* are the most wide spread. Like eucalyptus acacias are also planted either on the grassy downs up to the cliff line or in the sheltered folds of the hills after removing the sholas. The altitude is also similar. Acacia and gymnospermic *Callitris* and *Cupressus* plantations are totally devoid of any undergrowth chiefly because of excessive darkness, and other climatological and biotic factors. The same may be said of *Pinus patula* plantation.

Eucalyptus and acacia plantations cover *c*. 25,000 h. in the district.

Along the edges of tea, coffee and eucalyptus plantations, and on the banks of streams flowing through them, there are always luxuriant undergrowths. These are mostly composed of *Pilea*, *Pouzolzia*, *Lasianthus*, *Oldenlandia*, *Osbeckia*, *Microtropis*, *Rubus*, *Lantana*, *Cestrum aurantiacum*, *Datura*, *Sophora*, *Rumex*, *Rhododendron arboreum*, *Ipomoea*, *Passiflora*, *Toddalia*, *Dodonaea*, *Hypericum*, *Maesa*, *Elaeagnus* etc. In tea and eucalyptus plantations there are only two storeys—canopy and undergrowth.

Other than the plantations mentioned above, a vast area of grassy downs have been covered by introduced exotic plants like *Ulex europaeus*, *Eupatorium glandulosum*, *Cytisus scoparius* and *Lantana camara*.

Results and Discussion

The birds observed in the sholas above 1500 m tea, and in plantations of eucalyptus and acacia, all above 1500 m, have been shown in Table 1.

Altogether 118 species of resident, migratory and locally migratory birds have been observed in the evergreen forests and sholas which also occurred in the tea, eucalyptus or acacia plantations. There occur 112 species in the sholas, 86 in tea, 76 in eucalyptus and 62 in acacia. The number of species present in tea and eucalyptus are far fewer than in the sholas. Acacia supports the lowest number of species. In tea each species is represented by larger number of individuals and those in eucalyptus and in acacia by fewer.

There are 28 resident species in tea, 14 in eucalyptus and 10 in acacia against 64 in the sholas. The abundance of individuals of each species in tea and paucity of breeding birds in eucalyptus—acacia plantations may be because the latter support fewer number of food bearing plants, insects and other food animals. These foods are less abundant in eucalyptus and almost absent in acacia. It is also likely that the clear felling of eucalyptus and acacia every 10 years, and regular lopping of eucalyptus branches throughout this period is disastrous to the birds and their food items.

The migratory and locally migratory bird species which visit natural vegetations equally prefer plantations. Out of 16 migratory species 9 are found in tea, 9 in eucalyptus and 7 in acacia.

Adaptiveness of some species :

Among the 118 species recorded, there are a few which are better adapted to the tea plantation proper, i.e., excluding the shrubs along the streams and thinned-out sholas. In order of abundance and success they are : Redwhiskered Bulbul, Ashy Wren-Warbler, Spotted Munia, Pied Bush Chat, Brown Shrike, Rufousbacked Shrike, Jungle Babbler, Grey Junglefowl, Painted Bush Quail, Blackbird, Spotted Babbler and Blackwinged Kite as resident, Tickell's Leaf—, Blyth's Reed—and Greenish Leaf Warblers, Grey Drongo, Blueheaded Rock Thrush, Brown Flycatcher, Brownbreasted Flycatcher, and Rosefinch as migratory species. There are other birds which are frequently seen in the tea but usually do not breed there in any number. These are all species of babblers mentioned in Table 1, Woodpeckers, Flycatchers, Barbets, Bee-eaters, Bulbuls, White-eye, Crows and Grey Tit. The Flowerpeckers and Sunbirds are frequent visitors to the tree parasites viz. *Dendrophthoe Loranthus* and *Viscum* on shade trees.

The resident species benefit from the available food, nesting facilities, shelter and roosting places. The migratory species utilize the available food resources, especially insects. Most migrants are insectivorous. Other species visit tea but do not stay there chiefly because of non-availability of suitable nesting facilities. But they use the food materials and cover as Gray (1974) has observed in eucalyptus

TABLE 1

BIRDS OBSERVED IN THE SHOLAS AND IN THE PLANTATIONS

Serial No.	Synopsis No.	Name of the Birds[1]	Occurrence and status in			
			Shola	Tea	Eucalyptus	Acacia
1.	124	Blackwinged Kite *Elanus caeruleus*[1]	FR[2]	UCr	O	—
2.	133	Pariah Kite *Milvus migrans* ..	O	Fr	O	O
3.	138	Shikra *Accipiter badius* ..	UCR	O	O	O
4.	145	Crested Goshawk *Accipiter trivirgatus*	F	—	—	—
5.	151	Besra Sparrow-Hawk *Accipiter virgatus* ..	UCR	O	O	O
6.	163	Bonelli's Hawk-Eagle *Hieraaetus fasciatus* ..	O	O	O	O
7.	172	Black Eagle *Ictinaetus malayensis*	F	F	—	—
8.	187	Scavenger Vulture *Neophron percnopterus* ..	O[3]	O[3]	—	—
9.	195	Short-toed Eagle *Circaetus gallicus* ..	FM	—	—	—
10.	197	Crested Serpent Eagle *Spilornis cheela*	CR	O	—	—
11.	224	Kestrel *Falco tinnunculus* ..	—	F	F	F
12.	262	Painted Bush Quail *Perdicula erythrorhynchos* ..	FR	Cr	F	—
13.	275	Red Spurfowl *Galloperdix spadicea* ..	FR	O	—	—
14.	301	Grey Junglefowl *Gallus sonneratti* ..	UCR	Cr	Cr	F
15.	405	Wood Snipe *Capella nemoricola* ..	FM	—	—	—
16.	411	Woodcock *Scolopax rusticola* ..	CM	—	O	—
17.	511	Imperial Pigeon *Ducula badia* ..	FR	—	—	—
18.	521	Nilgiri Wood Pigeon *Columba elphistonii* ..	CR	—	O	—
19.	537	Spotted Dove *Streptopelia chinensis*	CR	Cr	F	F
20.	542	Emerald Dove *Chalcophaps indica* ..	UCR	—	—	—
21.	550	Roseringed Parakeet *Psittacula krameri*	—	Fr	—	—
22.	564	Bluewinged Parakeet *Psittacula columboides*	CR	—	—	—
23.	567	Indian Lorikeet *Loriculus vernalis*	F	Fr	F	F lm[1]
24.	571	Pied Crested Cuckoo *Clamator jacobinus* ..	O	O	—	—
25.	590	Koel *Eudynamys scolopacea* ..	FR	—	—	—
26.	602	Crow-Pheasant *Centropus sinensis*	FR	F	Fr	O
27.	628	Forest Eagle-Owl *Bubo nipalensis*	UCR	—	—	—
28.	659	Brown Wood Owl *Strix leptogrammica* ..	UCR	—	—	—
29.	685	Indian Edible-nest Swiftlet *Collocalia unicolor*	F[2]	—	—	—
30.	694	Alpine Swift *Apus melba* ..	F[2]	—	—	—
31.	703	House Swift *Apus affinis* ..	F[2]	F[2]	—	—
32.	724	Common Kingfisher *Alcedo atthis* ..	UCR	—	—	—
33.	736	Whitebreasted Kingfisher *Halcyon smyrnensis* ..	UCR	O	—	—
34.	744	Chestnutheaded Bee-eater *Merops leschenaulti*	C	C	C	F
35.	750	Green Bee-eater *Merops orientalis* ..	CR	Cr	C	F

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[1] Subspecies name has not been included as no specimen was collected.

[2] VC-Very common, seen during *c.* 80-100% of the visits; C-Common, 50 to 80%, UC-Uncommon, 25 to 50%, F—Few, below 25%; R—Resident in the sholas, r—resident in the plantations; O—Occasional, visiting from the nearby forests; and M—Migratory.

[3] Seen overhead.

[1] lm—Locally migratory.

[2] Seen overhead.

TABLE 1—(*Contd.*)

Serial No.	Synopsis No.	Name of the birds	Occurrence and status in			
			Shola	Tea	Eucalyptus	Acacia
36.	765	Hoopoe *Upupa epops*	FR	Cr	F	F lm[1]
37.	785	Small Green Barbet *Megalaima viridis*	VCR	C	—	—
38.	799	Speckled Piculet *Picumnus innominatus*	FR	—	—	—
39.	808	Little Scalybellied Green Woodpecker *Picus xanthopygaeus*	F	Cr	F	F
40.	820	Lesser Goldenbacked Woodpecker *Dinopium benghalensis*	CR	F	O	O
41.	825	Indian Goldenbacked Threetoed Woodpecker *Dinopium javense*	UCR	—	—	—
42.	847	Yellowfronted Pied Woodpecker *Dendrocopus maharattensis*	F	UC	F	F
43.	853	Pigmy Woodpecker *Picoides nanus*	CR	F	F	—
44.	862	Larger Goldenbacked Woodpecker *Chrysocolaptes lucidus*	FR	—	—	—
45.	914	Dusky Crag Martin *Hirundo concolor*	F	F	F	F[1]
46.	919	House Swallow *Hirundo tahitica*	—	F	F	O[1]
47.	927	Striated Swallow *Hirundo daurica*	—	FM	FM	FM
48.	947	Rufousbacked Shrike *Lanius schach*	F	UCr	F	—
49.	949	Brown Shrike *Lanius cristatus*	F	Cm	C	F
50.	953	Golden Oriole *Oriolus oriolus*	FR	O	—	— lm
51.	965	Grey or Ashy Drongo *Dicrurus leucophaeus*	UCM	UCM	FM	O
52.	982	Ashy Swallow-Shrike *Artamus fuscus*	F[1]	F[1]	—	—
53.	1010	Jungle Myna *Acridotheres fuscus*	CR	O	O	O
54.	1016	Hill Myna *Gracula religiosa*	O	—	—	—
55.	1049	House Crow *Corvus splendens*	O	O	O	O
56.	1054	Jungle Crow *Corvus macrorhynchos*	CR	Cr	UCr	UCr
57.	1065	Pied Flycatcher-Shrike *Hemipus picatus*	CR	Cr	UCr	UCr
58.	1070	Common Wood Shrike *Tephrodornis pondicerianus*	CR	F	F	—
59.	1079	Blackheaded Cuckoo-Shrike *Coracina melanoptera*	UCR	O	—	—
60.	1081	Orange (Scarlet) Minivet *Pericrocotus flammeus*	CR	O	O	O
61.	1104	Goldfronted Chloropsis *Chloropsis aurifrons*	—	O	—	—
62.	1114	Greyheaded Bulbul *Pycnonotus priocephalus*	CR	—	—	—
63.	1120	Redwhiskered Bulbul *Pycnonotus jocosus*	VCR	VCr	Cr	UC
64.	1128	Redvented Bulbul *Pycnonotus cafer*	VCR	VCr	Cr	UC
65.	1144	Yellowbrowed Bulbul *Hypsipetes indicus*	CR	O	O	O
66.	1149	Black Bulbul *Hypsipetes madagascariensis*	VCR	Cr	Cr	UC
67.	1154	Spotted Babbler *Pellorneum ruficeps*	CR	Cr	Cr	Cr
68.	1174	Slatyheaded Scimitar Babbler *Pomatorhinus schisticeps*	CR	O	O	—
69.	1224	Blackheaded Babbler *Rhopocichla atriceps*	CR	—	O	O
70.	1260	Rufous Babbler *Turdoides subrufus*	O[1]	F	—	—

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[1] Seen overhead.

Serial No.	Synopsis No.	Name of the Birds	Occurrence and status in			
			Shola	Tea	Eucalyptus	Acacia
71.	1264	Jungle Babbler *Turdoides striatus*	FR	VCr	F	—
72.	1307	Nilgiri Thrush *Garrulax cachinnans*	CR	F	UC	—
73.	1390	Quaker Babbler *Alcippe poioicephala*	CR	F	F	—
74.	1407	Brown Flycatcher *Muscicapa latirostris*	FM	O	FM	FM
75.	1408	Brownbreasted Flycatcher *Muscicapa muttui*	FM	O	FM	FM
76.	1411	Redbreasted Flycatcher *Muscicapa parva*	FM	—	—	—
77.	1427	Black-and-Orange Flycatcher *Muscicapa nigrorufa*	CR	O	UCr	Fr
78.	1435	Whitebellied Blue Flycatcher *Muscicapa pallipes*	F	—	—	—
79.	1442	Tickell's Blue Flycatcher *Muscicapa tickelliae*	VCR	Fr	Fr	Fr
80.	1446	Nilgiri Flycatcher *Muscicapa albicaudata*	VCR	Fr	Fr	Fr
81.	1449	Greyheaded Flycatcher *Culicicapa ceylonensis*	VCR	F	F	F
82.	1457	Whitespotted Fantail Flycatcher *Rhipidura albogularis*	VCR	F	UCr	Fr
83.	1461	Paradise Flycatcher *Terpsiphone paradisi*	F	—	—	—
84.	1513	Plain (Nilgiri) Wren-Warbler *Prinia subflava*	—	Fr	F	—
85.	1517	Ashy Wren-Warbler *Prinia socialis*	F	VCr	F	—
86.	1535	Tailor Bird *Orthotomus sutorius*	FR	O	—	—
87.	1556	Blyth's Reed Warbler *Acrocephalus dumetorum*	VCM	UCM	CM	FM
88.	1579	Tickell's Leaf Warbler *Phylloscopus affinis*	CM	CM	CM	FM
89.	1602	Dull Green Leaf Warbler *Phylloscopus trochiloides*	FM	FM	FM	O
90.	1637	Rufousbellied Shortwing *Brachypteryx major*	CR	—	F	O
91.	1650	Blue Chat *Erithacus brunneus*	VCM	CM	CM	FM
92.	1661	Magpie Robin *Copsychus saularis*	CR	UC	F	O
93.	1702	Pied Bush Chat *Saxicola caprata*	UCR	Cr	F	O
94.	1723	Blueheaded Rock Thrush *Monticola cinclorhynchus*	CM	FM	O	O
95.	1726	Blue Rock Thrush *Monticola solitarius*	O	O	—	—
96.	1728	Malabar Whistling Thrush *Myophoneus horsfieldii*	FR	F	O	O
97.	1731	Pied Ground Thrush *Zoothera wardii*	FM	—	—	—
98.	1734	Whitethroated Ground Thrush *Zoothera citrina*	FR	F	F	—
99.	1742	Nilgiri Thrush *Zoothera dauma*	C ?	—	O	O
100.	1753 1755	Blackbird *Turdus merula*	UCR	Cr	F	F
101.	1794	Grey Tit *Parus major*	CR	Cr	F	F
102.	1811	Yellowchecked Tit *Parus xanthogenys*	CR	—	O	—
103.	1834	Velvetfronted Nuthatch *Sitta frontalis*	CR	—	O	O
104.	1870	Nilgiri Pipit *Anthus nilghiriensis*	CR	F	Fr	Fr
105.	1874	Forest Wagtail *Motacilla indica*	FM	—	O	O
106.	1884	Grey Wagtail *Motacilla caspica*	VCM	CM	FM	FM
107.	1899	Tickell's Flowerpecker *Dicaeum erythrorhynchos*	CR	F	—	Cr
108.	1902	Nilgiri Flowerpecker *Dicaeum concolor*	CR	F	—	Cr

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[1]—This species is common in Tea plantation below 1000 m.

TABLE 1—(*Contd.*)

Serial No.	Synopsis No.	Name of the Birds	Occurrence and status in			
			Shola	Tea	Eucalyptus	Acacia
109.	1907	Purplerumped Sunbird *Nectarinia zeylonica*	F	—	—	—
110.	1909	Small Sunbird *Nectarinia minima*	VC	C	O	O locally migratory
111.	1917	Purple Sunbird *Nectarinia asiatica*	CR	UCr	F	O
112.	1931	Little Spiderhunter *Arachnothera longirostris*	F	—	—	F locally migratory
113.	1935	White-eye *Zosterops palpebrosa*	VCR	F	Cr	F
114.	1938	House Sparrow *Passer domesticus*	O	F	O	O
115.	1964	Red Munia *Estrilda amandava*	F	—	O	—
116.	1971	Rufousbreasted Munia *Lonchura kelaartii*	FR	O	—	—
117.	1974	Spotted Munia *Lonchura punctulata*	F	VCr	O	O
118.	2011	Common Rosefinch *Caprodacus erythrinus*	VCM	FM	O	O

plantation. By and large all birds of tea plantation are either resident or migratory species of sholas from where they have apparently moved to the plantations.

The commonest resident species of eucalyptus plantation include Redwhiskered Bulbul, and Spotted Babbler. Others who build nests here are Jungle Crow, Black-and-Orange Flycatcher, Nilgiri Verditer Flycatcher, Tickell's Blue Flycatcher, Whitespotted Fantail Flycatcher, Pied Flycatcher-Shrike, Black Bulbul, Nilgiri Pipit and White-eye. All these shola species opportunistically settle in this plantation mainly because of the good undergrowth and food. These species are either insectivorous or are omnivorous. The Lorikeet and the Haircrested Drongo (*Dicrurus hottentottus* not in my study plots) are usually attracted by eucalyptus flowers for the nectar (Ali and Ripley 1968-74).

The Jungle Crow, Spotted Babbler and Flowerpeckers are the commonest resident species of acacia plantations. Some of the flycatchers do build nests here. They utilize insects, caterpillars, worms and seeds of tree parasites as food (Flowerpeckers) and seedlings or bushy tree tops as nesting sites. The first two species are not dependent on acacia alone as they forage over a larger area and are not as parochial as the others.

So far as food, shelter, and breeding places are concerned eucalyptus and acacia plantations provide poor environment as is evidenced by the paucity of breeding birds. Here the disadvantage of monoculture is more clearly noticeable than in tea plantation.

Appraisal and Comments :

From the rate at which sholas are disappearing from the upper plateaux of the Nilgiris it can be conjectured that, unless the process is halted immediately, hardly any area will support these types of forest by the beginning of the next century. Therefore, bird species which are adapted for these vegetations will be crowded into small pockets or galleries of forest to be found along streams in the different plantations, specially tea. Some might disappear totally. Others may move towards less suitable moist-deciduous habitats on the lower plateau.

To save the avifauna and other animals of the sholas of the Nilgiris there is no alternative to stopping all further denudation of this unique ecosystem. All clear felling should be banned, although controlled selective felling may be allowed to a limited extent. Trees removed by such process should be replaced only by native trees. Adequate measures should be taken to save the undergrowth and shrubs in the eucalyptus and acacia plantations. All perennial sources of water and vegetation on their banks should be preserved.

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NECTAR-FEEDING ADAPTATIONS OF FLOWERBIRDS[1]

P. KANNAN[2]

(*With twenty-two text-figures*)

INTRODUCTION

The bill and tongue of birds usually show special adaptations to facilitate procurement of their staple food and their method of feeding. Striking examples of such adaptations may be seen in the bill and tongue of woodpeckers, adapted respectively to boring holes in tree barks and extracting worms from within the crevices, and in the lamellated bill and tongue of ducks and flamingoes (also the long neck) adapted to filtering their food from water. Likewise, the bill of specialized nectar-feeding birds is adapted to probe flowers for nectar and their tongue (as also the bill) to suck it up.

Many structural and behavioural features of flowerbirds that are seemingly not directly involved in nectar-feeding have been described by earlier writers on the subject as nectar-feeding adaptations. The hovering habit of hummingbirds (Trochilidae) has been described as an adaptation to feed from flowers that do not offer a landing place for the birds. The comparatively small size and swift direct flight of sunbirds (Nectariniidae), flowerpeckers (Dicaeidae), honeyeaters (Meliphagidae) and brush-tongued lories (Trichoglossidae, now merged with Psittacidae) have been described as adaptations to facilitate flying through dense foliage and their perching type of feet as an adaptation to cling to the twigs in different ways while flower-probing. The validity of these interpretations is open to question, for all these so called nectar feeding adaptations could be explained as adaptations for other functional requirements of the birds that are apparently much older and more basic than nectar-feeding.

As flowerbirds and birdflowers have evolved together, each in adaptation to the other, it may, perhaps, be impossible to determine some adaptive features of either of them as 'the cause' or 'the effect' of correlative features of the other. But, structural features of the bill and tongue of specialized nectar-feeding birds, developed in them, exclusively for fulfilling a subjective need, are evidently true nectar feeding adaptations.

This study was undertaken by me during 1963-66 as a part of my M.Sc. dissertation on Ornithophily. The study area included natural forests in and around Bombay and two hill stations namely, Khandala and Mahabaleshwar in Western Ghats, Maharashtra.

METHOD

With the view to determining the nectar feeding adaptations of flowerbirds, I examined, where necessary under microscope, the shape, size and structure of bills and tongues of 37 species of flowerbirds of the study area listed in Appendix I. Transverse Sections of different parts of tongues of specialized nectar-feeders were examined under microscope to note the shape of the organ in different species. In some cases, I made a comparative study of forms closely related to nectar-feeders but adapted to fruit-eating or insect-catching. Also, I observed in the laboratory live specimens of specialized nectar-feeders of the study area for closer observation of the working mechanism of their tubular tongues.

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[1] 'Flowerbirds' and 'Birdflowers': I have used the expression 'Flowerbird' to indicate that the bird is a habitual flower visitor to feed on nectar without any reference to the extent of adaptation for nectar feeding shown by its bill and tongue or to its role in flower pollination. So also, the expression 'birdflower' as used here only means that the flower is visited by birds for its nectar and does not necessarily mean an ornithophilous flower.

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As a part of study of Ornithophily, I observed the visits of 37 species of flowerbirds to 50 species of flowers in the Bombay area. These observations form the basis of data furnished in Table 2. Details of these observations are recorded in a separate paper (in press).

OBSERVATIONS

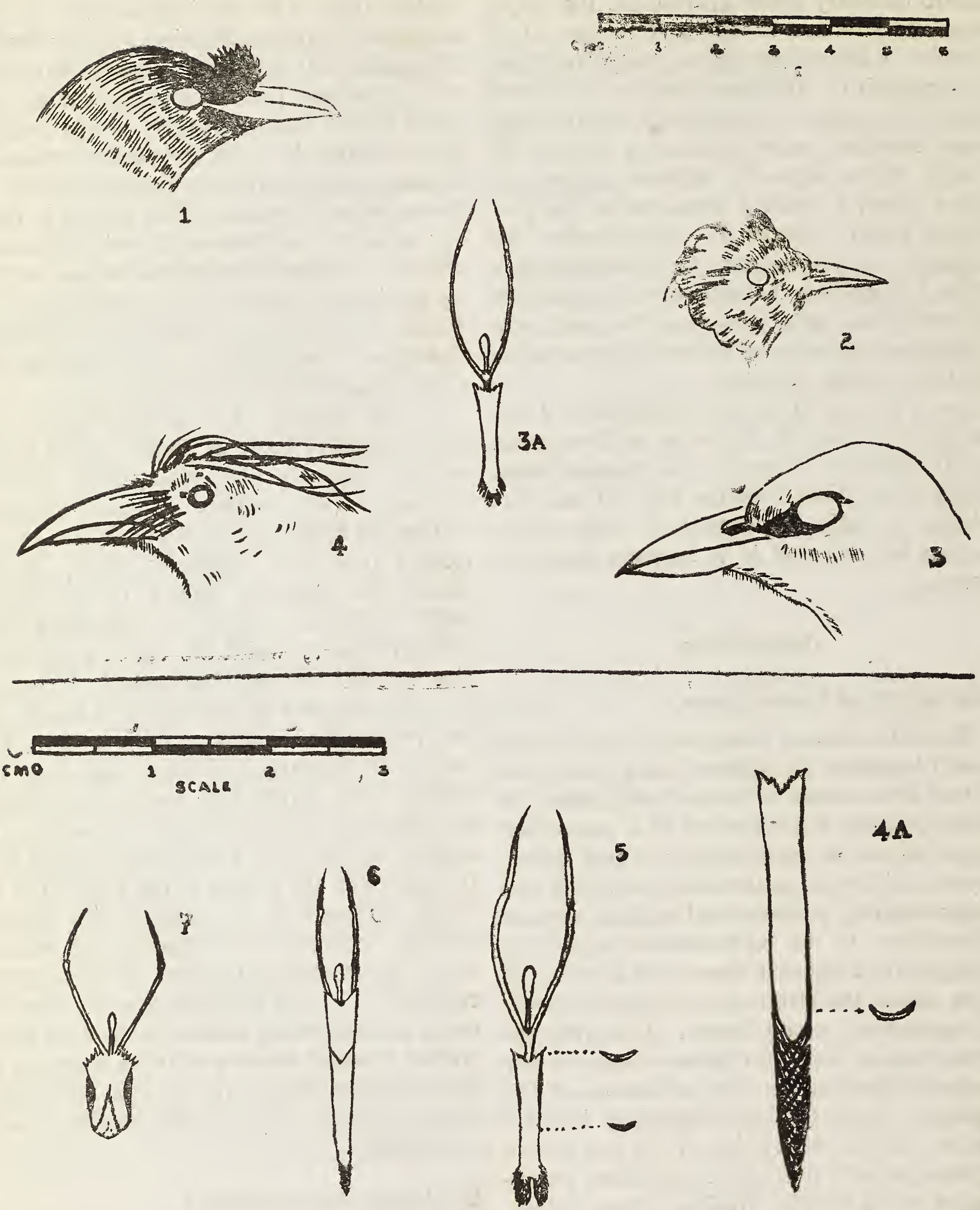
Non-specialized Nectar-feeders :

The list of flower frequenters of the study area (Appendix I) includes many birds, the bills of which show no special adaptation for flower-probing, but are either of a generalized nature to suit an omnivorous diet (e.g. crows, mynas, orioles) or nut-cracking and fruit and seed-eating (e.g. parakeets and lorikeet), or show adaptations to an insectivorous diet (e.g. drongo), the tongues of these birds also do not show any of the elaborate adaptations shown by specialized nectar-feeders. However, the birds frequent and also cross-pollinate a few species of flowers. In view of absence of any elaborate nectar-feeding adaptations in such species, detailed description of bill and tongue in these pages is restricted to spcialized nectar-feeders of the families Irenidae, Nectariniidae, Dicaeidae and Zosteropidae. The sketches of bills and tongues of non-specialized nectar-feeders (Figs. 1-7) are included with a view to explain characters exhibited by some species, though not all, such as the slightly curved bill with a pointed tip, the bifid tongue tip and slight frayed tongue margins in the anterior part resulting in a few bristle-like processes. These characters probably facilitate licking up flower-nectar through capillary action, in much the same way they presumably assist in drinking water. Non-specialized nectar feeders studied by me, include species from following families : Psittacidae, Oriolidae, Dicruridae, Sturnidae, Corvidae, Pycnonotidae and Muscicapidae (Timaliinae, Sylviinae and Turdinae).

Of the tongue of non-specialized nectar feeders studied, those of Indian Robin (*Saxicoloides fulicata*) and Haircrested Drongo (*Dicrurus hottentottus*) are of interest inasmuch as they are markedly better evolved for nectar-feeding than their respective closely related forms. The anterior tongue tip of Indian Robin is frayed into a few somewhat long bristly processes, which are curled upwards to give a brush-tip like appearance. However, the posterior part of the tongue is nearly flat and the tongue is not a suctorial organ. The tongue of Haircrested Drongo also has the anterior part frayed into many long bristles and the mid portion deeply concave by the marked curling in of the tongue margins that (compared to the tongue of the King Crow or Black Drongo) it is adapted for nectar-feeding. However, the tongue is not tubular and is not a suctorial organ. Beecher (1953) remarks '. . . . the adaptive loss of the bill notch and the nectar adapted tongue (of Haircrested Drongo) indicate a strong approach to flower-feeding, though the persistence of rictal bristles suggests that insect-catching is still paramount'.

Specialized Nectar-Feeders :

Lucas (1897) and Gardner (1925, 1927) studied adaptation of tongues of birds with



Bills and Tongues of non-specialised nectar feeders : (Figs. 1-7)—

1. *Acridotheres fuscus* ; 2. *Pycnonotus cafer* ; 3. *Oriolus oriolus* ; 3A. Tongue of *O. oriolus* ; 4. *Dicrurus hottentottus*; 4A. Tongue of *D. hottentottus*; 5. Tongue of *Acridotheres tristis* ; 6. Tongue of *Saxicoloides fulicata* and 7. Tongue of *Loriculus vernalis.*

specialized food and feeding habits, including the tubular tongues of specialized nectar feeders. Gadow (1883) described in detail the structure of the tongue of *Nectarinia splendida*—an African sunbird and the method of functioning of the organ. He has compared sunbird's tongue with that of the Australian honey-eaters. Beddard (1891) described the nectar feeding adaptations seen in the tongue of the White-eye *Zosterops simplex*. Other contributors to the subject include Moller (1930, 1931), the first, a general account of the tongue of flower-seeking birds and the next, on the nectar-feeding adaptations of *Zosterops annulosa* ; Scharnke (1930, 1931, 1932), the first two being accounts of the adaptive modifications and working mechanism of the tongue of hummingbirds, and the last, an account of tongue structure of sunbirds, sugar-birds of South Africa and Hawaiian honeysuckers.

IRENIDAE

Birds studied: *Chloropsis aurifrons* and *C. cochinchinensis*.

Food habit : Both species feed on insects, spiders, flower nectar and a variety of fruits.

Bill : (Fig. 8). In both the species the bill is long (Culmen *c*. 2 cm), thin, slightly decurved and with a pointed tip. Rictal and nasal bristles are absent. The ventral surface of the upper mandible is deeply concave.

Tongue : (Fig. 17&17A). The tongue patterns of both the species are similar. The organ is stiff, *c*. 3 cm (excluding the hyoid) and slightly decurved to suit the shape of the bill in which it is enclosed.

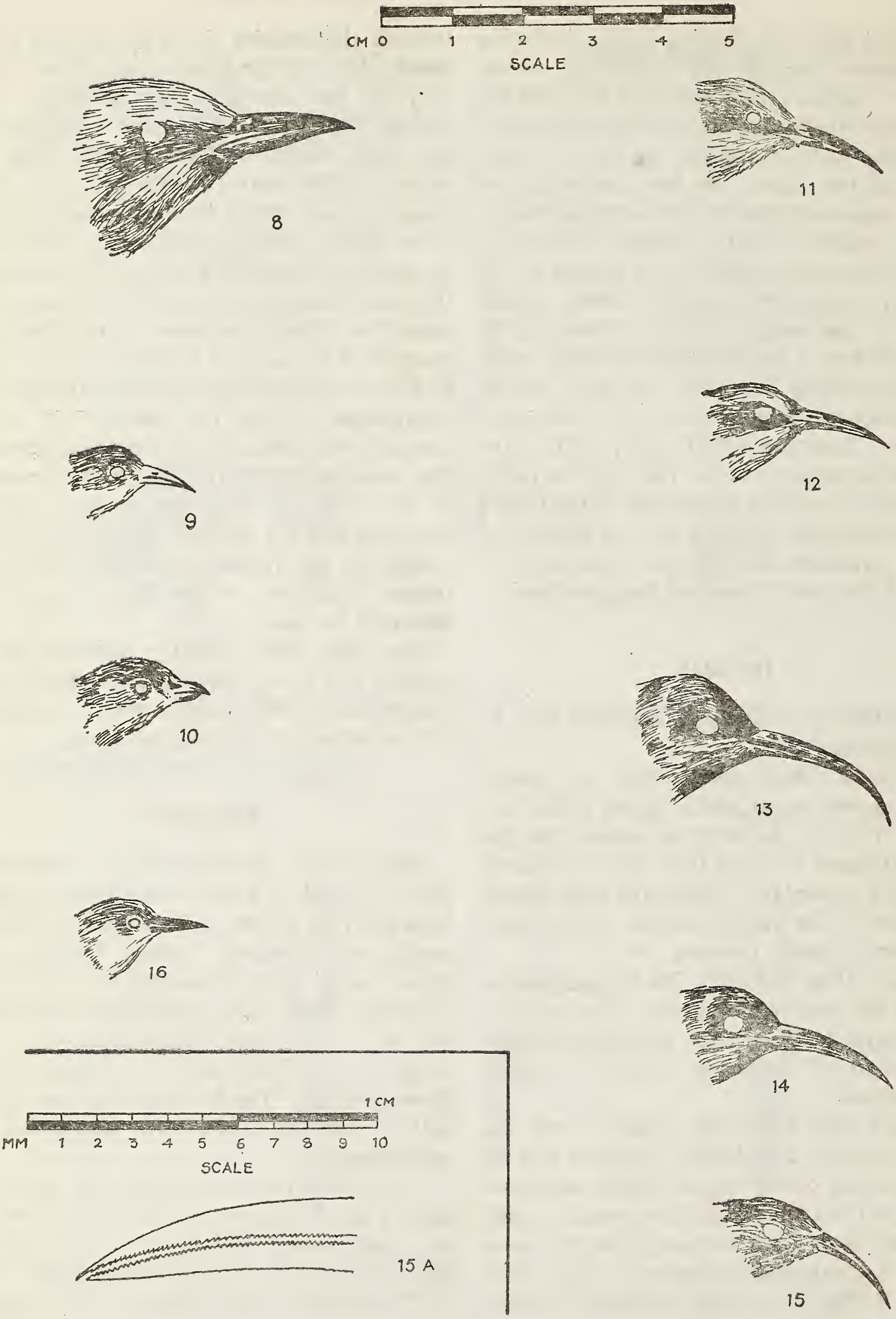
Some 5 mm from the posterior end, the tongue margins are slightly upturned and the dorsal surface of the tongue slightly depressed. Further in front, the margins are turned upwards more and more ; this feature giving the dorsal surface a trough-like appearance. The dorsal sheath within the trough becomes narrower towards the anterior tip of the tongue and is deeply cleft. In the anterior half of the tongue, only the two sheaths form the organ. The sheaths lose their connections with the stiff and bony elements of the tongue. The free edges of the ventral sheath that are curled upwards, now curled inwards as well, the two edges almost meeting each other. The outer, upturned margins of the ventral sheath, beyond the trough-like section, are frayed deeply into many long bristly processes. Since the frayed margins of the anterior tongue-tip curl inwards and meet each other, the bristles of the two sides intermingle to give the anterior tip of the tongue (for *c*. 9 mm) a brush-tip-like appearance. The dorsal sheath in this region is represented in the form of two long narrow flap-like processes that are enclosed within the ' brush ' formed by the ventral sheath (Fig. 17A). The tongue functions in the same manner as described for sunbirds.

The long, thin, slightly decurved bill is suitable for flower probing ; the highly protrusible semi-tubular tongue with its brush-like tip specialized for sucking up nectar.

DICAEIDAE

Birds studied : *Dicaeum agile*, *D. erythrorhynchos*. *D. agile* is mainly frugivorous, and has been observed to feed on the berries of different species of *Loranthus*, *Viscum*, *Lantana*, and *Ficus* ; rarely visits flowers to feed on nectar. The thick, short, sturdy and somewhat triangular bill of *D. agile* (Fig. 10) indicates that it is adapted to fruit-eating but is unsuitable for flower-probing. The flat tongue of this species, with a bifid tip, shows no adaptation for nectar-feeding.

D. erythrorhynchos also feeds on fruits, but takes a large quantity of flower nectar, as well as small insects and spiders. This species (Fig. 9) has a comparatively thin, long (*c* 12 mm) bill. The tomia of the anterior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Bill of specialised nectar feeders : (Figs. 8-16)—

8. *Chloropsis aurifrons* ; 9. *Dicaeum erythrorhynchos* ; 10. *D. agile* ; 11. *Nectarinia zeylonica* ; 12.*N. minima* ; 13. *N. lotenia* ; 14. *N. asiatica* ; 15. *Aethopyga siparaja* ; 15A. Sunbird's bill tip showing serrated tomia ; 16. *Zosterops palpebrosa.*

part of the maxilla and mandible are serrated, a characteristic feature of the two closely related families, Dicaeidae and Nectariniidae.

The comparatively thin bill of *D. erythrorhynchos* permits feeding on insects and flower nectar in addition to small pulpy fruits which appear to form their staple diet. The serrations of tomia in the anterior part of the bill probably help in getting better grip over the fruits that are skilfully manipulated in that part of the bill for removal of the unwanted seed-coat. Ali (1931) has pointed out that the remarkable difference in the shape and size of the bills of these two closely related species of flowerpeckers is reflected in their different ways of feeding on the same food item viz., fruits of Loranthus. The thin pointed bill without bristles around its base facilitates its insertion into the narrow tubular corolla of ornithophilous flowers.

The tongue of *D. erythrorhynchos* (Fig. 18) is *c.* 15 mm long. The margins of the ventral sheath, after losing their connection with the dorsal sheath, are turned upwards and inwards to make this part of the tongue somewhat tubular ; but the two upturned margins do not contact each other to make it completely tubular. The anterior one third of this semi-tubular part of the tongue is deeply split into two equal sized 'secondary tubes'. These two secondary tubes are semi-tubular, each with its concave side turned towards the other, that is, if the two half tubes were to unite they would form a complete tube. The margins of the tongue are entire (without fraying or incisions). The tip of the secondary tubes are slightly bifid. According to Beecher (1953) the tongue of flowerpeckers functions in the same way as that of sunbirds.

NECTARINIDAE

Birds studied : Nectarinia zeylonica, N. minima, N. lotenia, N. asiatica and *Aethopyga siparaja.*

Food and feeding habits : The flower visiting habit of sunbirds is well known. Flower nectar seems to be the main food of these birds. The two methods of reaching the nectar, i.e. probing the flower through the regular flower opening and the 'short cut method' have been recorded by many observers. Besides flower nectar, the birds feed on a large quantity of small spiders and insects.

As the general pattern of bills and tongues of all species of sunbirds examined so far appear similar in most aspects, generalized descriptions of the organs are given. However, as the bill size in the different species varies, measurements of the organ in all specialized nectar feeders differences are also pointed out (Table 1).

TABLE 1

MEASUREMENTS OF AVERAGE LENGTH OF BILL AND CULMEN OF 9 SPECIES

Species	Bill length in mm (from skull)	Culmen length in mm
Chloropsis aurifrons	23	19
C. cochinchinensis	22.5	19
Dicaeum erythrorhynchos ..	11.5	9.5
Nectarinia zeylonica ..	18	15.5
N. minima ..	16.5	12
N. lotenia ..	27	23.5
N. asiatica ..	21	17
Aethopyga siparaja ..	23	19.5
Zosterops palpebrosa ..	11.5	10

Bill : The bill of all sunbirds is long, slender slightly decurved and with a pointed tip. Near the base, it is somewhat flattened dorsoventrally. Towards the anterior tip, it gradually becomes more and more slender and tapers to a very sharp point. When the bill is closed, the anterior part, from about the middle of its entire length, is somewhat tubular.

The bill is decurved to varying extents in different species. Within the genus *Nectarinia*, the curvature is apparently directly proportional to the length of the organ. The diagrams of the bills of all sunbirds of the study area show that *N. lotenia* (Fig. 13) has the longest and the most decurved bill ; the bill of *N. zeylonica* (Fig. 11) is slightly smaller and less curved than the bill of *N. asiatica* (Fig. 14) and *A. siparaja* (Fig. 15). The very thin bill of *N. minima* (Fig. 12) is the shortest and in shape resembles that of *N. zeylonica.*

Just as in *D. erythrorhynchos*, the tomia (edges) of both the maxilla and mandible are projected into small teeth-like processes. When the bill is closed the serrations of the upper mandible fit into the gaps between the serrations of the lower mandible (Fig. 15A).

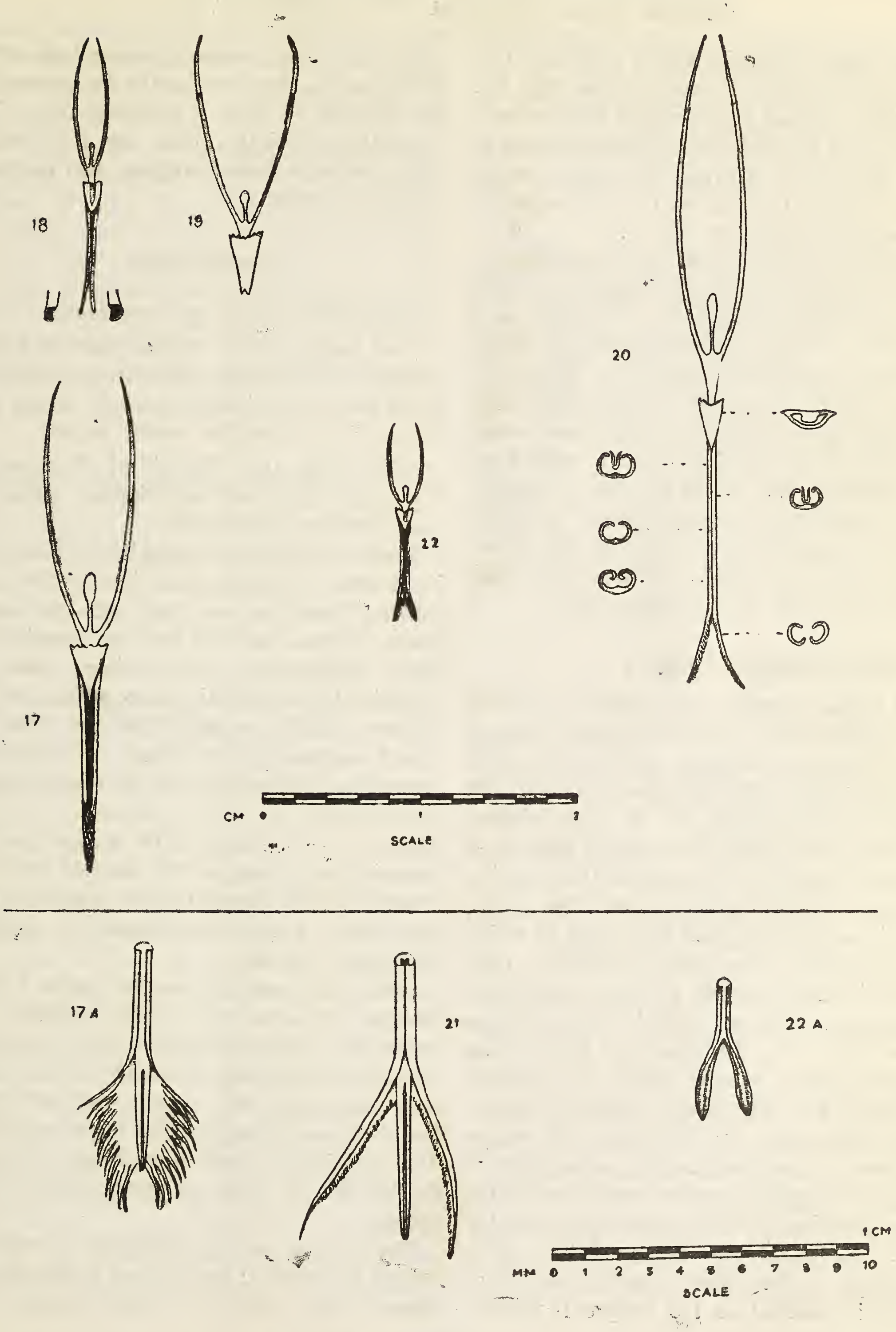
The long thin decurved bill of sunbirds is highly suited to flower-probing and nectar feeding. The bill of *Certhia*—the tree creepers, is curiously somewhat similar in shape to the sunbird's bill. Here again the shape of the bill is known to be an adaptation to probe among the tree barks for small insects and their larvae which are eaten by these birds. The evolution of this probing, decurved thorn-like bill in Certhidae, a group which is only distantly related to Nectariniidae emphasises the fact that the primary adaptation of this type of bill is to probe the source of food supply. In this context, the similarity in the shape of the bills of sunbirds and many Australian Honey-eaters (Meliphagidae) is also significant.

The long bill of the sunbirds enables them to reach the nectar of even long-tubed flowers. As a moderate length of the tube is covered by the bill, the task of protruding the tongue to reach the nectar is made easy. The sharp tip of the bill, besides facilitating the insertion of the organ into narrow corolla tubes, the characteristic shape of highly evolved ornithophilous flowers, is also helpful in pricking holes on the sides of corolla (described by earlier workers as ' the short-cut method ') to reach the nectar of many flowers apparently not adapted to receive sunbirds. The concave midventral surface of the maxilla plays an important role in sucking up flower-nectar. The bill also shows adaptations to capture spiders and flying insects. The increase in the length of the organ, evolved, possibly mainly as an adaptation to probe flowers, has increased the gape of the birds in a vertical plane. The bill of sunbirds, while capturing spiders and flying insects, is put to use in the same way as that of bee-eaters. The serrations of the tomia of the anterior part of the bill possibly constitute an adaptation to get a good ' grip ' over the insect prey that is held in that part.

Tongue : Gadow (1883) has given a detailed and accurate account of the structure and working mechanism of the tongue of *N. splendida.* His description is generally applicable to the tongues of all sunbirds studied by me.

The long, thin tongue (Fig. 20) is highly bent downwards so as to suit the bill shape. Transverse sections of sunbirds' tongue show the extent to which the margins of the ventral sheath are curled upwards to make it tubular. The dorsal sheath is markedly depressed. In front of the posterior flat portion its continuity with the ventral sheath is gradually lost, the depression increases in depth and the sheath forms a deep longitudinal groove in the mid-dorsal surface : This is clearly seen in the sections. The free edges of the ventral sheath curl upwards and inwards to meet each other above the mid-dorsal surface of the tongue and form a complete tube. The two edges neither fuse with each other nor overlap one another, after meeting each other but curl a little more inwards as shown in the cut end of Fig. 21. This complete tube encloses the half tube formed by the dorsal sheath.

In the four species of *Nectarinia*, the anterior part of the tongue is represented only by the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Tongue of specialised nectar feeders : (Figs. 17-22)—

17. *Chloropsis aurifrons* (entire) ; 17A. *C. aurifrons* tongue tip enlarged ; 18. *Dicaeum erythrorhynchos* ; 19. *D. agile* (non-specialised) ; 20. *Nectarinia zeylonica*, sections indicate extent of tubulation in different parts ; 21. *Aethopyga siparaja*, tongue tip ; 22. *Zosterops palpebrosa* ; 22A. *Z. palpebrosa*, tongue tip.

ventral sheath which is deeply split into two almost wholly tubular secondary tubes (Fig. 20). The highly reduced dorsal sheath extends only upto the part where the ventral sheath begins to split. But in *A. siparaja* the dorsal sheath extends beyond this part to the full length of the tongue as shown in Fig. 21.

The inner margins of the secondary tubes of all the five species are deeply incised into several lobes. According to Gadow (1883) this is a characteristic feature of all species of sunbirds.

Observations on the method of feeding on diluted honey by captive sunbirds show that the tongue alone, in its protruded state, comes into contact with the liquid that is sucked up, that whenever this organ is put to use it is moved forward and backward (in and out of the beak) very rapidly and that during such movements it is pressed against the palate, the latter acting as the axis for its articulation.

Working Mechanism of Tongue :

The tongue together with larynx is pressed up against the roof of the mouth by the contraction of *Musculo mylohyoideus* and *serpihyoideus* which underlie it. The tongue is then protruded because of the action of *M. geniohyoideus* and at the same time the back part of the tongue along with the larynx is depressed, thus creating a vacuum between the tongue and the palate. Into this vacuum will flow any liquid in which the tongue may have been immersed. Thus sucking is accomplished by mere protrusion of the organ. Gadow (1883) is of the opinion that to begin with, the laciniae or lobes of the secondary tubes absorb liquid by capillary action and then the tubular region with the margin entire, sucks up liquid from the secondary tubes. According to him absorption of the liquid by capillary action would prevent the air from rushing into the tongue along with the liquid. It should also be noted that while functioning in the above manner, creation of vacuum is possible as the tongue is pressed against the deep concave mid-ventral surface of the maxilla, thus covering the gap between the two margins to form a complete tube. This observation indicates that the bill, besides being useful in flower probing, also facilitates sucking up nectar.

ZOSTEROPIDAE

Bird studied : Zosterops palpebrosa.

Food habits : This species feeds on a large quantity of Loranthus berries and other such pulpy fruits ; also insects collected mostly from leaves. It is a regular nectar feeder.

Bill : (Fig. 16). The bill of *Z. palpebrosa* is straight, short and sharp-tipped. Rictal and nasal bristles are absent.

Tongue : (Fig. 22). Tongue is *c.* 2.25 cm long, its posterior end produced into a few small spines. Posterior one third of the tongue proper is flat and stiff but the anterior two third membranous and flexible. Near the posterior tip the dorsal surface is flat, but just in front of this posterior flat part, the mid-dorsal surface of the tongue is slightly depressed and the margins of the tongue slightly upturned but not curled inwards. At about one third of the length of the tongue from the posterior end, the upturned margins are curled inwards slightly, but as the two margins do not meet each other, the tongue is nowhere completely tubular.

Just at this region where the tongue is most tubular the dorsal and ventral sheaths that cover the tongue surface on their respective sides and united along the margin of the tongue where they come into contact with each other, lose their connection between them completely. The extensions of the thin, membranous, highly flexible sheaths form the anterior half of the tongue.

The anterior part of the tongue is made up of two semi-tubes : two formed by the divided dorsal sheath and two of the ventral. The divisions of each sheath show a tendency to be apart. Hence the anterior part of the tongue is made up of two bundles, each consisting of one half each of dorsal and ventral sheaths (Fig. 22A). The outer margins of the two halves of the ventral sheath and the inner margins of the dorsal sheath are frayed into many small bristles. As these half tubes are with their concave sides opposed to each other, the bristles of set of dorsal and ventral sheaths intermingle to give the tip of the tongue a double brush-tip-like appearance.

The tongue of this species functions in the same way as that of sunbirds.

ANALYSIS, DISCUSSION AND CONCLUSION

The foregoing account of the bill and tongue of the flowerbirds of the study area shows that they fall into two natural groups: 1. The non-specialized nectar feeders with licking type of bill and tongue which includes all flowerbirds of the study area except those included in the second group and 2. Specialized nectar feeders with suctorial mouth-parts to which the two species of *Chloropsis*, *D. erythrorhynchos*, all five species of sunbirds, and *Z. palpebrosa* belong.

All specialized nectar feeders of the study area excepting the two species of *Chloropsis* belong to the phylogenetically related families Dicaeidae, Nectariniidae and Zosteropidae. Utilization of flower nectar by most members of these families is a striking common feature between them. This affinity has prompted Beecher (1951) and others to group them into ' Asiatic nectar feeding assemblage '.

Bill : The nine species of specialized nectar feeders possess comparatively thin, long bills which are suitable for flower probing. The absence of bill hook and of rictal bristles facilitates insertion of the bill into narrow tubular corollae of ornithophilous flowers. The average bill length and the length of the culmen of specimens collected from the study area are given in Table 1. The measurements indicate that the organ (except in the two *Chloropsis*) is of different lengths in the different species. The sketches of the bills of these species show that the shape of the organ is also a variable factor.

Tongue : The tongue of specialized nectar feeders of the study area exhibits characters which have been described by authorities as nectar feeding adaptations. These characters are tubular tongue, splitting of its anterior part, fraying or incisions of the margin of the secondary tubes and increased protrusibility of the organ. It is interesting to note that in all cases tubular condition is secured by the curling upwards and inwards of the margins of the ventral sheath. But as indicated in the descriptions of the specialized tongues of these species, only sunbirds' tongue is completely tubular; in all other cases the organ being only semi-tubular. In the case of *D. erythrorhynchos* it is almost entirely tubular. However, the tongues of all the four groups are truly suctorial and function on more or less the same basis.

The tongues of these specialized nectar feeders, in spite of the remarkable similarity in the assumption of a tubular form are clearly of different patterns. The basic nectar feeding adaptations of the tongue already described, appear in these groups in different combinations. Gardner (1927) has pointed out that ' . . . any one or all these tendencies may be exaggerated, modified or combined to form the highly adapted tongues of flower-frequenters, each after its own pattern'.

No two species of specialized nectar feeders of the area have identical mouth parts but interspecific differences exist either in the shape or size of their bills and tongues. Of the 9 species of specialized nectar feeders, sunbird possesses the most highly evolved and apparently the most efficient bill and tongue for nectar feeding and the rest are less highly evolved for the purpose. This difference suggests that sunbirds are dependent upon flower nectar to a greater extent than other specialized nectar feeders.

The above interpretation is supported by the general food habits of these species. *Chloropsis* spp., *D. erythrorhynchos* and *Z. palpebrosa* feed on large quantity of fruits and insects in addition to flower-nectar, but sunbirds' diet is limited to nectar and insects. The long thin decurved bills of sunbirds, adapted to probe flowers and catch spiders and insects, are clearly unsuitable for feeding on fruits. This structural over-specialization for a nectar and insect diet has, presumably, increased the need for the only other food item of the Asiatic nectar feeding assemblage rich in carbohydrates, namely flower nectar, and made it an indispensable part of sunbirds' diet.

With the view to note whether this increased need of nectar by sunbirds is reflected in their greater diligency in visiting flowers, I collected field data on visits by the 37 species of flower-birds to 50 species of flowers of the study area. Appendix II includes a list of 50 species of birdflowers of the study area. Table 2 given below is a summary of the number of flowers visited by birds of different families. The 50 birdflowers of the study area are classified into five groups according to their pollinators. The number of flowers in each group is also given in parentheses.

The striking feature of the data furnished above is that sunbirds visit all fifty birdflowers of the study area ; the others in comparison, visiting only very few flowers. Of these 50 species, only 14 ornithophilous flowers are indigenous to the study area. All lepidoptera-adapted flowers and most melittophilous and exotic ornithophilous flowers are visited only by sunbirds. This clearly shows that the ability to make use of non-ornithophilous flowers as sources of nectar is most highly developed in sunbirds and that the same is either absent or poorly developed in the others.

TABLE 2

NUMBER OF FLOWERS VISITED BY BIRDS OF DIFFERENT FAMILIES

Family	Indigenous ornithophilous flowers (14)	Exotic ornithophilous flowers (14)	Butterfly flowers (10)	Bee-pollinated flowers (11)	Bat pollinated flowers (1)	Total No. of flowers (out of 50) noted to be visited by each family
PSITTACIDAE ..	5	1	—	2	—	8
ORIOLIDAE ..	6	—	—	—	—	6
DICRURIDAE ..	5	—	—	1	—	6
STURNIDAE ..	6	1	—	2	1	10
CORVIDAE ..	4	1	—	2	—	7
IRENIDAE ..	12	1	—	1	—	14
PYCNONOTIDAE ..	7	1	—	1	—	9
MUSCICAPIDAE ..	7	1	—	1	1	10
DICAEIDAE ..	11	1	—	—	—	12
NECTARINIIDAE ..	14	14	10	11	1	50
ZOSTEROPIDAE ..	6	—	—	—	1	7

Of the other flowerbirds, the two groups of specialized nectar-feeders Irenidae and Dicaedae, (almost all the observed visits related to *D. erythrorynchos*) visit a larger number of flowers than any other group. White-eye is seen only rarely in Greater Bombay and all observations on flower visits by White-eye were made during brief visits to hill stations in the Western Ghats. The small number of flowers noted as visited by them is due to the short period of observation. It is important to note that almost all flowers visited by these specialized nectar feeders are only indigenous ornithophilous flowers and that the ability to make use of the nectar of non-ornithophilous flowers, so well developed in sunbirds, is not marked in these birds. The flower-visits of non-specialized nectar feeders are limited to a few species, mostly indigenous ornithophilous forms.

Thus, of the flowerbirds studied only sunbirds combine the most highly evolved structural adaptations for nectar-feeding resulting in an increased need of nectar with the ability to make use of the nectar of the largest number of flowers, including those not adapted to receive their visits.

This ability to make use of non-adapted flowers as sources of nectar is mainly, although not entirely, due to acquisition of a new behavioural pattern, i.e. the short-cut method of nectar-feeding. Of the 37 species of non-adapted flowers at least 21 are frequently robbed of their nectar by sunbirds. Field observations suggest that, but for the short-cut method it would be impossible for sunbirds to reach the nectar of most of these flowers. This emphasizes the selective value of the short-cut method as a behavioural adaptation.

Habitual employment of the short-cut method to feed on the nectar of non-adapted flowers has been noticed in two other bird families of specialized nectar feeders, namely Honey-eaters of Australia and Hummingbirds. Even among insects, many members of the two groups of specialized nectar feeders, carpenter bees (Hymenoptera) and Hawkmoths (Sphingidae ; Order Lepidoptera) have been noted to make use of the nectar of non-adapted flowers by boring holes at their base. It is well known that for these specialized nectar-feeders, flower nectar is indispensable and all have structural specializations of mouth parts leading to limitation or total exclusion of food items other than flower nectar.

Since sunbirds share the nectar of most entomophilous birdflowers only with insects, their regular pollinators, the intensity of competition between them and other flowerbirds of the study area for flower nectar is reduced, and their task of collecting nectar is made easy. This seems to be a factor that has facilitated the extraordinary high specialization of their bills for nectar feeding. This conclusion gains strength from the fact that like sunbirds, other specialized nectar feeders, earlier referred to, also exhibit the ability to make use of the nectar of non-adapted flowers. Thus, the evolutionary ill effects of high specialization for a narrow food-niche (namely nectar of flowers adapted to receive their visits) are overcome, at least to an appreciable extent, by this increased ability to obtain the food.

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APPENDIX I

FLOWERBIRDS OF THE STUDY AREA

ORDER : PSITTACIFORMES

PSITTACIDAE

1. *Psittacula krameri* (Scopoli), Roseringed Parakeet
2. *Loriculus vernalis* (Sparrman), Indian Lorikeet

ORDER : PASSERIFORMES

ORIOLIDAE

3. *Oriolus oriolus* (Linnaeus), Golden Oriole
4. *O. xanthornus* (Linnaeus), Blackheaded Oriole

DICRURIDAE

5. *Dicrurus adsimilis* (Bechstein), Black Drongo or King Crow
6. *D. caerulescens* (Linnaeus), Whitebellied Drongo
7. *D. hottentottus* (Linnaeus), Haircrested or Spangled Drongo

STURNIDAE

8. *Sturnus malabaricus* (Gmelin), Greyheaded Myna
9. *S. roseus* (Linnaeus), Rosy pastor
10. *Acridotheres tristis* (Linnaeus), Common Myna
11. *A. fuscus* (Wagler), Jungle Myna.

CORVIDAE

12. *Dendrocitta vagabunda* (Latham), Indian Tree Pie
13. *Corvus splendens* Vieillot, House Crow
14. *C. macrorhynchos* Wagler, Jungle Crow

IRENIDAE

15. *Chloropsis aurifrons* (Temminck), Goldfronted Chloropsis
16. *Ch. cochinchinensis* (Gmelin), Goldmantled Chloropsis

PYCNONOTIDAE

17. *Pycnonotus jocosus* (Linnaeus), Redwhiskered Bulbul
18. *P. cafer* (Linnaeus), Redvented Bulbul

MUSCICAPIDAE

Timalinae

19. *Pellorneum ruficeps* Swainson, Spotted Babbler
20. *Chrysomma sinensis* (Gmelin), Yellow-eyed Babbler
21. *Turdoides caudatus* (Dumont), Common Babbler
22. *T. striatus* (Dumont), Jungle Babbler
23. *Alcippe poioicephala* (Jerdon), Quaker Babbler

Sylviinae

24. *Prinia subflava* (Gmelin), Longtail Warbler
25. *P. socialis* Sykes, Ashy Longtail Warbler
26. *Orthotomus sutorius* (Pennant), Tailor Bird

Turdinae

27. *Copsychus saularis* (Linnaeus), Magpie Robin
28. *Saxicoloides fulicata* (Linnaeus), Indian Robin
29. *Turdus merula* Linnaeus, Blackcapped Black Bird

DICAEIDAE

30. *Dicaeum agile* (Tickell), Thickbilled Flowerpecker
31. *D. erythrorhynchos* (Latham), Tickell's Flowerpecker

NECTARINIDAE

32. *Nectarinia zeylonica* (Linnaeus), Purplerumped Sunbird
33. *N. minima* (Sykes), Small Sunbird (observations on this species made in the Western Ghats)
34. *N. lotenia* (Linnaeus), Loten's Sunbird
35. *N. asiatica* (Latham), Purple Sunbird
36. *Aethopyga siparaja* (Raffles), Yellowbacked Sunbird

ZOSTEROPIDAE

37. *Zosterops palpebrosa* (Temminck), White-eye (Observations on this species made only in the Western Ghats)

APPENDIX II

BIRDFLOWERS OF THE STUDY AREA

MALVACEAE

1. *Hibiscus rosasinensis* Linn.
2. *Thespesia populnea* (Linn.)

BOMBACACEAE

3. *Salmalia malabarica* (DC.)
4. *S. insignis* (Wall.)

STERCULIACEAE

5. *Erythropsis* (= *Sterculia* = *Firmiana*) *colorata* Roxb.
6. *Helicteres isora* Linn.

MORINGHACEAE

7. *Moringa oleifera* Lamk. (= *Moringa pterygosperma* Gaertn.)
8. *Sesbania grandiflora* Pers.
9. *Erythrina variegata* Linn. (= *E. indica* Lamk.)
10. *Erythrina suberosa* Roxb.
11. *Butea monosperma* (Lamk.)

CAESALPINIACEAE

12. *Caesalpinia pulcherrima* Swartz. (= *Poinciana pulcherrima* Linn.)
13. *Bauhinia variegata* Lamk.
14. *B. purpurea* Linn.

MIMOSACEAE

15. *Samanea* (= *Pithecolobium* = *Enterolobium* = *Mimosa*) *saman* Prain
16. *Calycopteris floribunda* Lamk.
17. *Quisqualis indica* Linn.

MYRIACEAE

18. *Eucalyptus* (?) *globulus* Lab.
19. *Callistemon* (?) *lanceolatus* (DC.)

LYTHERACEAE

20. *Woodfordia fruticosa* (Linn.)

ONAGRACEAE

21. *Fuchsia* spp.

CARICACEAE

22. *Carica papaya* Linn.

RUBIACEAE

23. *Ixora coccinea* Linn.
24. *Hamelia patens* Jacq.

APOCYANACEAE

25. *Theyetis neriifolia* Juss.

CONVOLVULACEAE

26. *Ipomoea cairica* Linn. (= *I. palmata* Forsk.)
27. *I. angulata* Lamk. (= *I. coccinea* Clarke / = *Quamoclit coccinea* Cooke)

SCROPULARIACEAE

28. *Russelia juncea* Zucc.

BIGNONIACEAE

29. *Millingtonia hortensis* Linn.
30. *Spathodea campanulata* Beauv.
31. *Tecoma stans* (Linn.)

ACANTHACEAE

32. *Graptophyllum pictum* (Linn.) (= *Justisia picta* Linn. *Graptopbyllum hortense* Nees)

VERBENACEAE

33. *Lantana camara* Linn.
34. *Clerodendrum* Linn.
35. *Duranta repens* Linn. (= *D. plumieri* Jacq.)
36. *Holmskioldea sanguinea* Retz.
37. *Petrea volubilis* Linn.

LABIATAE

38. *Salvia coccinea* Tuss.
39. *Bougainvillea spectabilis* Willd.

PROTEACEAE

40. *Grevillea robusta* Cunn.

LORANTHACEAE

41. *Dendrophthoe f.* var. *pubescens* (Linn.) (=*Loranthus falcata* Linn. = *L. longiflorus* Dest. & *D. f.* Etting. var. *coccinea* (Talb.)
42. *Helicanthes elastica* (Desr.) (= *Loranthus elasticus* Desrouss)
43. *Helixanthera obtusata* (Schult.) (= *Loranthus obtusatus* Wall.)
44. *Macrosolen capitellatus* (Wt. & Arn.) (= *Loranthus capitellatus* Wt. & Arn.)

POPULATION AND ROOSTING BEHAVIOUR OF MIGRATORY ROSY PASTOR *STURNUS ROSEUS* IN POONA, MAHARASHTRA STATE

Anil Mahabal and D. B. Bastawde[1]

(*With seven text-figures*)

INTRODUCTION

The Rosy Pastor or the Rosecoloured Starling *Sturnus roseus*, (Fam. Sturnidae) is one of the most abundant and notable of the terrestrial migrants to India. This highly social bird is one of the earliest migrants to India arriving as early as August, and one of the last to depart leaving as late as April or early May. During its stay in India it is particulary common in the north-western parts of the sub-continent and in southern peninsula. It moves over the countryside in large flocks whose appearance in different parts of the country is a notable event and the movements of the rosy pastor in various parts of India have been discussed by a number of authors (Ali 1931, Abdulali 1947, Krishnan 1955, Khan and Sharma 1976). We have made observations on the populations of the rosy pastor visiting Poona city over a three year period from 1973 to 1976. These observations reveal that the number of rosy pastors visiting Poona in different months of the year is remarkably constant from year to year reaching the maximum in late March or early April. We have also found that the behaviour of the rosy pastor at the communal roosts changes from the time of their first arrival in autumn to the time of their departure in spring.

MATERIALS AND METHODS

These observations are part of an overall programme of a study of the major species forming communal roosts, in Poona city. We have located every one of the communal roosts of the common myna *Acridotheres tristis*, house crow *Corvus splendens*, jungle crow *Corvus macrorhynchos*, roseringed parakeet *Psittacula krameri*, pariah kite *Milvus migrans*, cattle egret *Bubulcus ibis* and pond heron *Ardeola grayii*. The rosy pastors invariably form their mixed communal roosts in company of the common myna and house and jungle crows. They are occasionally associated with the roseringed parakeet, cattle egret, pond heron, pariah kite, brahminy myna *Sturnus pagodarum* and house sparrow *Passer domesticus*. The rosy pastor was found to occur at six such communal roosts during various months of the year (Fig. 1). At each of these roosts we carried out monthly censuses over the period from June 1973 to May 1976. We maintained records of the number of flocks of rosy pastors arriving in the evening at the communal roost and the number of birds in each flock at five minute intervals. Rosy pastor flocks fly to the roost from definite directions and are clearly countable from a good distance. We have therefore every reason to believe that reliable total counts are available at every roost of the rosy pastor in the city. We have also maintained observations on the

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[1] Zoological Survey of India, Western Regional Station, Poona-411 016.

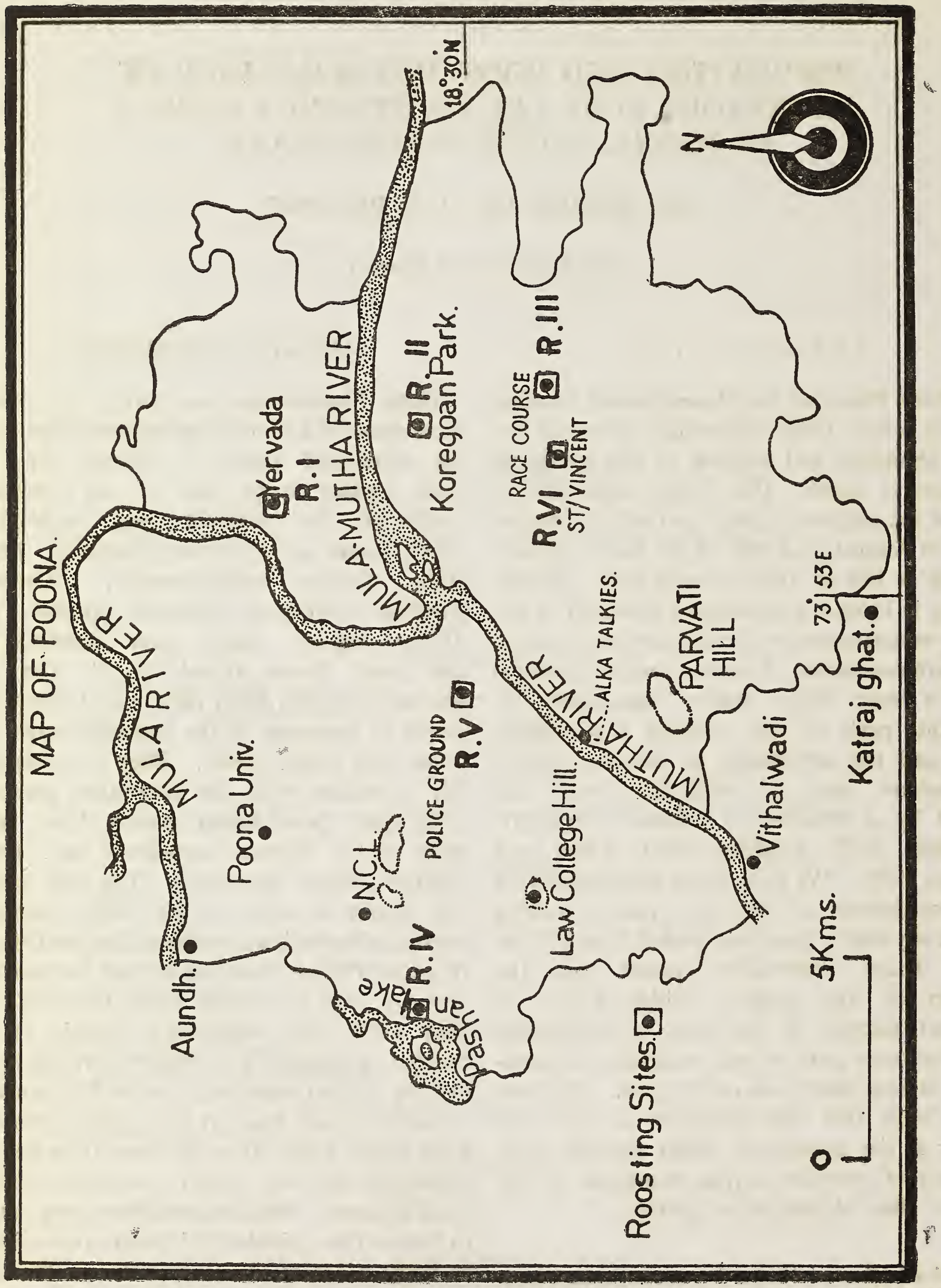
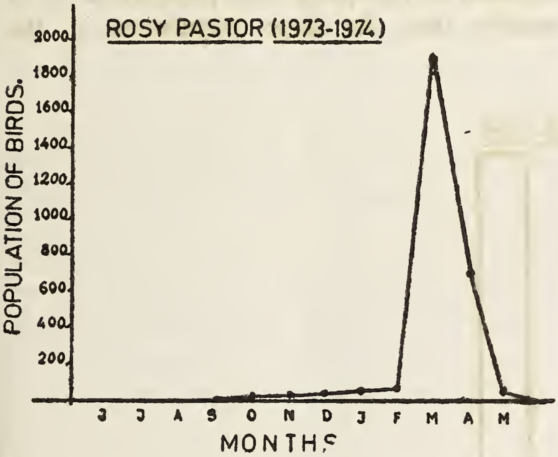

MAP OF POONA.
MULA RIVER
MULA-MUTHA RIVER
MUTHA RIVER
Yervada
R. I
R. II
Koregoan Park.
RACE COURSE
R. III
R. VI
ST/VINCENT
ALKA TALKIES.
PARVATI HILL
Poona Univ.
POLICE GROUND
R. V
N.C.L.
Law College Hill.
Vithalwadi
Aundh.
R. IV
Pashan lake
Roosting Sites.
0
5Kms.
Katraj ghat.
73° 53 E
18° 30 N
N

Fig. 1. Map of Poona city showing the location of the six rosy pastor roosts.

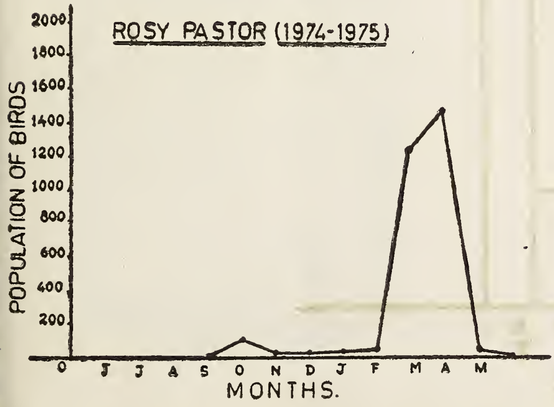
behaviour of this bird at the roosts with particular reference to pre-roosting displays.

POPULATION

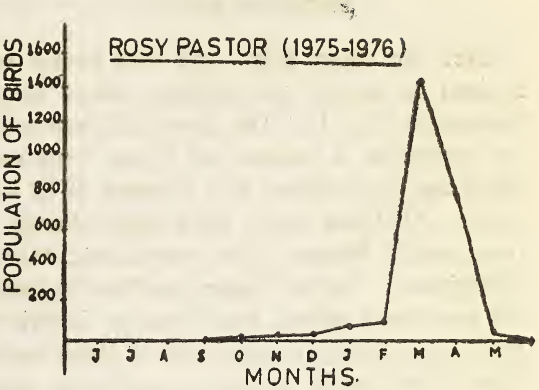
Figure 2 gives a picture of the population of the rosy pastor passing through Poona city during different months of the year. Birds are first noticed in small numbers in the month of October and persist at this low level till February. Total numbers in these months are just around fifty birds distributed amongst several roosts. Thus there are at this time small flocks of 6-15 birds scattered among the six different roosts. The population suddenly builds up to about 1500-1800 birds in the months of March and April. It appears likely that this wave is a part of the gradual northward movement of the rosy pastors from their wintering grounds in the southern peninsula. This period also coincides with the ripening of the Jowar crop and fruiting of a number of *Ficus* trees. Rosy pastors invade the jowar fields in large flocks ; they are also to be seen feeding on *Ficus* trees in company of other bird species such as the common myna, brahminy myna, redvented bulbul, and crimsonbreasted barbet. Most notably the rosy pastor population is concentrated in these spring months on just 1 or 2 major roosts. Of these, roost V, which happens to be the largest communal roost of the common myna as well, has the largest concentrations of the rosy pastor in the spring months of every year. The number of rosy pastors rapidly decreases in the month of May and they are totally absent in Poona from June to September.



a—1973-74



b—1974-75



c—1975-76

Fig. 2. Population of the rosy pastor in Poona city in different months of the year

ROOSTING SITES

Over the three years, the rosy pastor was noticed to occupy six different roosts in the Poona city (Fig. 1). The closest of these roosts are located at a distance of 2 kms from each other and the farthest at a distance of 12 kms apart. All these roosts have large clumps of trees mainly Banyan *Ficus bengalensis*, Mango *Mangifera indica* and Neem *Azadirachta indica*. As mentioned above, rosy pastors invariably roost in company of other birds at these roosts. Each of the species at these mixed roosts, however, forms its own concentration. Madhav Gadgil (Personal communication) has, however, observed one or two individuals of the rosy pastor flocking as well as completely mixing with the common Myna at a communal roost of common mynas in Poona in 1972, and similarly at Bandipur in 1978.

Figure 3 shows the population of the rosy pastor at each of these six roosts, averaged over the eight month period from October to May. It is evident that there is an overwhelming concentration of rosy pastors at roost V and roost II which are the only two roosts to be occupied by the spring large population. It is notable, that the large population in the

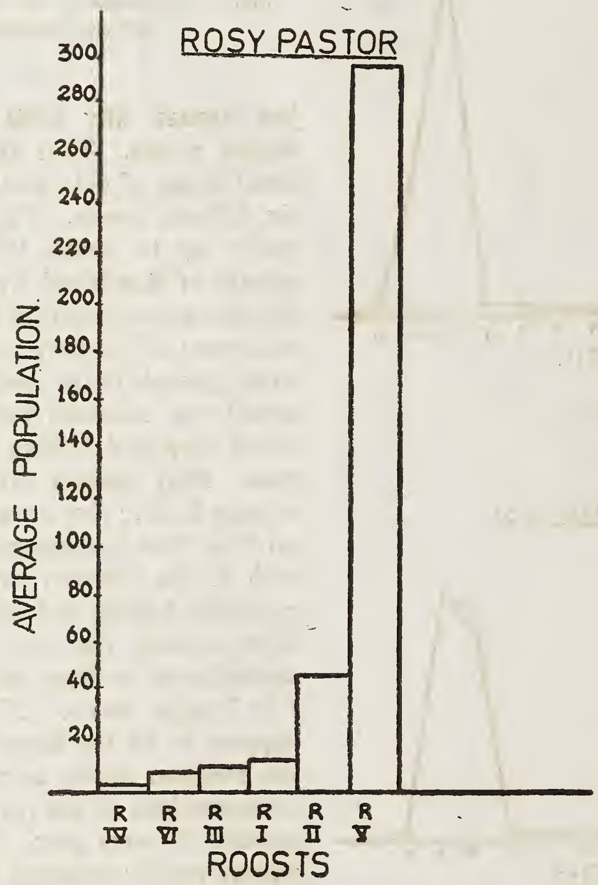


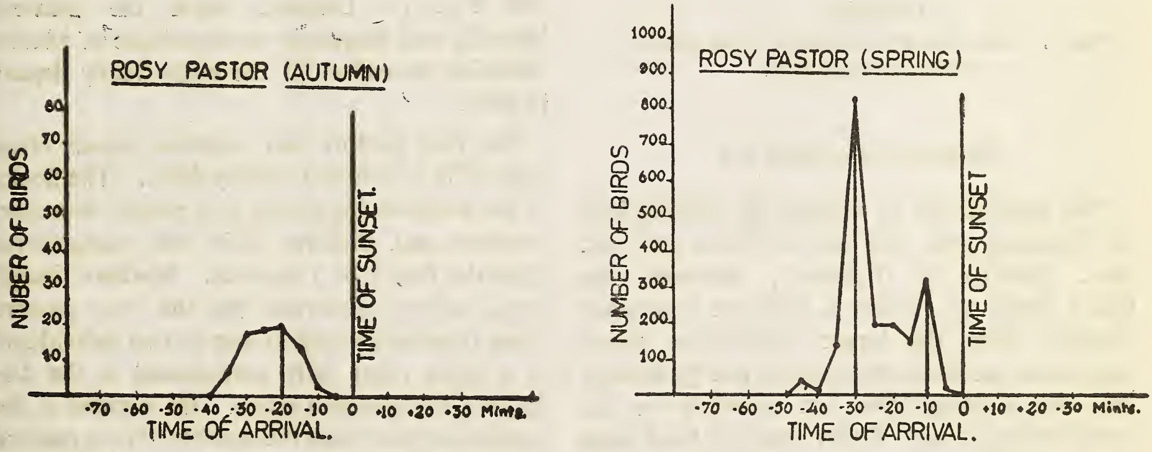
Fig. 3. Average population of the rosy pastor at each of the six roosts in Poona city.

spring confined its feeding activities entirely to the fields on the northern side of the Poona City.

ROOSTING BEHAVIOUR

As with other communally roosting birds rosy pastor flocks are dispersed over the feeding grounds during the day time. As the evening approaches flocks of rosy pastors begin to move in the direction of the communal roost. Such flocks come together at certain halting places which serve as ' assembly points '. The flocks gather strength as they meet other flocks on the way as well as at the assembly points. These flocks eventually reach the communal roosts over a short time-interval which remains very constant for a given species, for a given season. Figure 4 shows the number of rosy pastors arriving at the roost at five minute intervals for a typical autumn and a typical spring period. It will be noticed that the birds arrive a little later in relation to the time of sunset in autumn. The median time of arrival is 26 minutes before sunset for autumn with a mode at 20 minutes before sunset. In spring the median as well as mode at times of arrival are about 31 minutes before sunset. The time of arrival of flocks is spread over 35 minutes to 10 minutes before sunset in autumn. In spring the much larger number of birds show a greater spread in time of arrival from 45 to 5 minutes before sunset. The rosy pastor is the earliest of all the communal roosters roosting alongside it at the mixed roost. Of the other major associates of the rosy pastor, the common myna and the roseringed parakeet come somewhat later than the rosy pastor but largely before sunset to the roost. The pariah kite and both the house and the jungle crow follow after sunset.

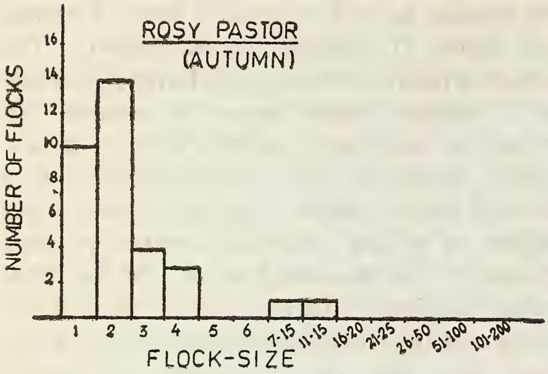
In autumn the very small population of the rosy pastor flies to the roost in very small flocks with the median at 2.4 and the maximum at 15.0. In the spring, however, the larger population at the roost leads to the formation of much bigger flocks with a median at 74 and a maximum at about 200. As Fig. 5 shows the flock size distribution is positively skewed in the autumn and negatively skewed in the spring.



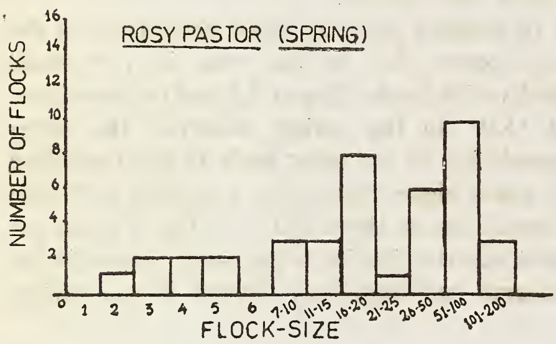
(a) Autumn

(b) Spring

Fig. 4. Time of arrival of rosy pastors at the communal roost R-V in relation to time of sunset.



(a) Autumn



(b) Spring

Fig. 5. Size of rosy pastor flocks flying into the communal roost R-V.

PRE-ROOSTING DISPLAYS

The small flocks of autumn fly directly into the roosting trees and do not show any display. Starting in February, however, the flocks begin to exhibit a different behaviour pattern. Now the larger flocks that arrive some what earlier to the roost do not fly directly into the roosting trees but assemble on the neighbouring trees. From time to time such flocks exhibit spectacular mass displays (see Fig. 6). The birds make a very low pitched soft noise for a few seconds as they synchronously take off for the display flights. The displaying flocks fly for 5-45 seconds performing a series of aerial manoeuvres. Circular and semicircular manoeuvres are the commonest forms of displays while zig-zag and ' S ' shape are only rarely observed. The displaying flocks varied in size from about 5-1000 birds (see Fig. 7). Displays reach the greatest intensity and frequency in the middle of March declining thereafter till the birds finally depart in May.

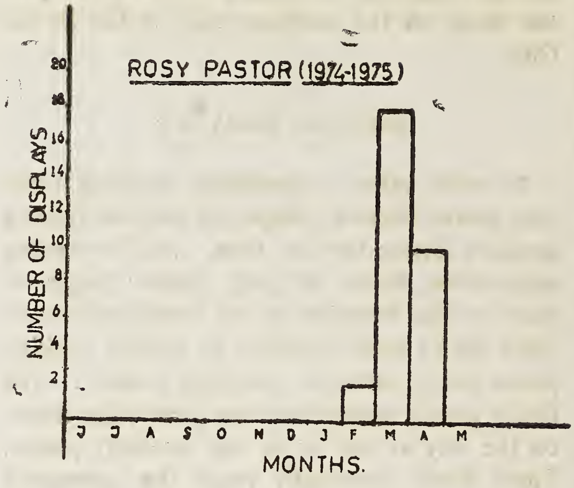


Fig. 6. Number of communal displays by the rosy pastor in different months of the year 1974-75 at the communal roost R-V.

The rosy pastors and common mynas often take off in a common display flight. The flocks of the common myna and rosy pastor, however, separate and perform their own manoeuvres after the first 2 or 3 seconds. Madhav Gadgil (Pers. comm.) observed that the rosy pastors when they occur only as one or two individuals at a myna roost fully participated in the displays of the common myna. He noticed at the same roost that when the number of rosy pastors increases to 10 or 15 they perform their separate displays. Although the house and jungle crows also perform aerial displays at the same

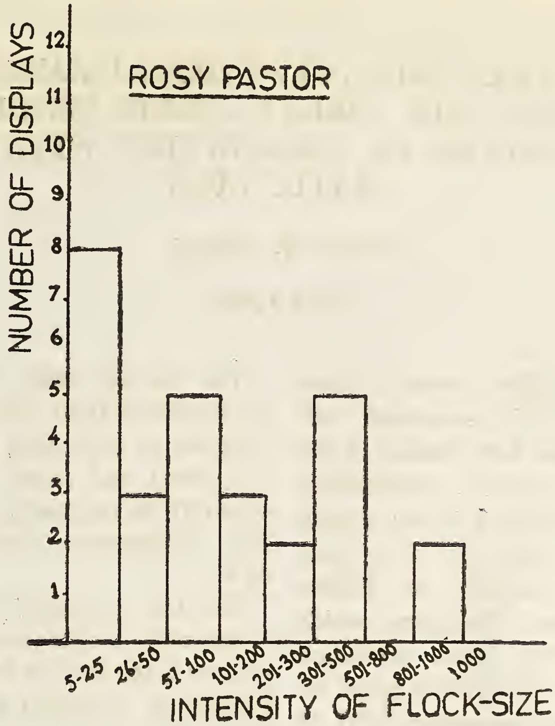


Fig. 7. Number of displays by flocks of various sizes at the communal roost R-V in 1974-75.

mixed roost at the same time the rosy pastors never join them in any display activity.

It is notable that this tendency of the rosy pastor to show large scale mass displays in the spring parallels the behaviour of a number of other communally roosting species which also display in their pre-breeding season. The displays of rosy pastor coincide not with a season of food scarcity as Ward and Zahavi (1973) have suggested but rather with a period of good food abundance with the ripening of the cereal crops and ripening of *Ficus* fruits.

ACKNOWLEDGEMENTS

We are grateful to Dr B. K. Tikader, Deputy Director, Zoological Survey of India, W.R.S., Poona for his encouragement and for the facilities provided. Prof. Madhav Gadgil of Indian Institute of Science, Bangalore stimulated this investigation and has helped in many phases of this investigation from the very beginning. We also wish to thank Mr. P. W. Garde, Artist of the Zoological Survey of India, W.R.S., Poona for his skillful rendering of the diagrams.

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THE GRIFFON VULTURES (*GYPS BENGALENSIS*, *G. INDICUS* & *G. FULVUS*) OF GIR FOREST: THEIR FEEDING HABITS AND THE NATURE OF ASSOCIATION WITH THE ASIATIC LION

ROBERT B. GRUBH[1]

(*With a plate*)

The feeding habits of griffon vultures (*Gyps* spp.) and the nature of their association with mammalian predators have been studied in the African continent by various researchers (Attwell 1963; Houston 1973 & 1974; Kruuk 1967 & Schaller 1972). But very little published information is available on Indian griffons in a natural forest. This paper which formed a part of my Ph.D. thesis submitted to the University of Bombay in1974 is based on observations made from September 1970 to July 1972 in the Gir Wildlife Sanctuary on the ecology and behaviour of the three griffon species occurring there namely the Whitebacked *G. bengalensis*, Longbilled *G. indicus* and the Fulvous *G. fulvus*. It deals with a few aspects of the feeding habits of griffon vultures, the extent of their appropriation of lion kills and the probable competition for food between vultures and the lion in the Gir forest.

STUDY AREA

The Gir Wildlife Sanctuary (21°10′N & 70°50′E) of Gujarat, western India is a 1265 km^2 area of hilly terrain with its boundary lying in the plains below the hills. The highest peak (Charakio) in the Gir hills is 638 m above mean sea level.

The Gir has three distinct seasons namely the monsoon (mid June to September), winter (October to February), and summer (March to mid June), and receives an annual rainfall of about 87 cm recorded in the wetter western Gir. The temperature fluctuates between 7° and 48°C.

The Gir is mainly a dry mixed deciduous forest with a high proportion of teak *Tectona grandis* in the western half, whereas thorn forests (*Acacia* & *Zizyphus*) and woodland savannah (*Boswellia serrata* and *Soymida febrifuga*) predominate in the east and south-east. Other common trees in the Gir include *Ficus* spp., *Terminalia tomentosa*, *Butea monosperma*, *Syzygium cumini* and *Sterculia urens*. The shrubs *Carissa carandas* and *Helicteres isora*, and grasses *Apluda mutica*, *Dicanthium annulatum* and *Schima nervosum* are typical of the area (Spillett 1968; Berwick, pers. comm.).

Among the larger mammals occurring in the Gir, the primary consumers include blacknaped hare *Lepus nigricollis*, sambar *Cervus unicolor*, chital *Axis axis*, nilgai *Boselaphus tragocamelus*, fourhorned antelope *Tetracerus quadricornis*, chinkara *Gazella gazella*, wild boar *Sus scrofa* and common langur *Presbytis entellus*. Such carnivores as the lion *Panthera leo persica* (Meyer), leopard *Panthera pardus*, jungle cat *Felis chaus*, civet cat *Viverricula indica*, striped hyena *Hyena hyena*, jackal *Canis aureus* and other animals including ratel *Mellivora capensis*, mongooses *Herpestes* spp. and pangolin *Manis*

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crassicaudata are prominent secondary and tertiary consumers.

Human influence : *Maldharis* (herdsmen) have been living inside the forest in kraals called nesses for over a century with their buffaloes and zebu cattle. There are about 137[2] nesses distributed all over the sanctuary (Mary Anne Berwick, unpublished). In addition to the nesses some settlement villages have been established by the government. The Forest Department have been organising ' lion shows ' for visitors to the sanctuary, in which about a couple of prides at a time are attracted to tied-up buffalo baits.

METHODS

1. Vultures were located at carcasses and their feeding habits observed. Carcasses were located mainly (i) by visiting nesses, (ii) through information received at the camp from maldharis and Forest Department personnel and (iii) by driving through the forest in jeep or on motorcycle and spotting vulture movment in the sky.

Vulture influence on carcasses was studied either by making repeated visits or by keeping continuous watch till the meat was completely consumed or became inaccessible through drying or other means. By sitting in a jeep or a portable hide it was possible to make close observations without disturbing the birds.

2. In case of lion kills the extent of meat consumption by the lion and others was visually estimated part by part, considering the total amount of meat accessible to the lion in each kill as 100. The visual estimate was aided by comparison with a chart (Table 1) showing percentage of meat available in various parts of

TABLE 1

PERCENTAGE OF MEAT AVAILABLE FOR LION IN DIFFERENT PARTS OF THE BODY OF THE CHIEF PREY SPECIES IN THE GIR

Parts of the body	Zebu cattle (1 female)	Water buffalo (3 females)
Head	6.3	6.2
Neck	6.9	7.5
Sternum and Clavicle	3.4	3.2
Thoracic vertebrae (anterior half)	5.3	4.8
„ „ (posterior half)	2.8	3.6
Lumbar	3.0	2.8
Intercostals	7.7	8.6
Hip and pubis	11.8	11.6
Abdomen wall	6.2	5.3
One foreleg (including scapula)	6.2	7.5
One foreleg in parts : Scapula	2.7	2.9
Humerus	2.3	2.6
Below knee	1.2	2.1
One hindleg (minus hip)	9.4	8.9
One hindleg in parts : Thigh	7.3	7.0
Below thigh	2.0	2.0
Heart	2.5	2.1
Lungs	7.6	6.2
Liver	5.4	4.0
Kidney	—	1.1

Intestines not included because the Gir lion avoids it although the Serengeti lion regularly eats it (Schaller 1972).

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[2] New maldharis are being shifted outside in a phased programme.

the body of the most abundant food species for the lion. This chart was prepared from results obtained by weighing carcasses of livestock part by part and reweighing the parts after removing the meat.

Observations were made only at natural kills and with care as not to disturb the lions. As long as lions were at a kill observations were made with binoculars from a distance, often from a hillock and it was only when lions were away that we (assistants and myself) took a brief close look at the kill. Keeping away from the kill was to enable the lion to be at ease and also to permit the normal course of scavenger activities. None of these kills were manipulated.

3. Mortality rate of domestic livestock was studied by making regular censuses in a selected number of nesses.

RESULTS AND DISCUSSION

Feeding Habits in General :

Griffon vultures live almost entirely on the soft tissues of large mammal carcasses (Kruuk 1967 ; Houston 1974). The griffon's beak is adapted to pull out soft tissues (Kruuk 1967). The head and neck, devoid of contour feathers, enable them to push the head deep into any opening in a carcass and scoop out meat.

In the Gir the griffons feed upon all soft tissues available in a carcass including tongue, eyes, muscles, heart, lung, intestine, and kidney, without apparent selectiveness. The only items left untouched are the skin, bones, cartilege and hard connective tissues surrounding them. Occasionally they also swallow pieces of old dry bones (Grubh 1973).

The griffons visited carcasses of domestic livestock as well as of wild animals, including water buffaloes, zebu cattle, camel, chital, sambar and nilgai. Although occurring in the Gir, animals such as chinkara, fourhorned antelope, wild boar and common langur were not found dead and being fed upon by vultures in natural conditions.

Food Supply :

(a) *Availability of food*

Animals die of predation as well as through other natural causes. Out of the 194 carcasses at which direct observation was made, 89 were due to natural causes other than predation, and 105 due to predation.

Domestic cattle and buffaloes contribute to the maximum number of carcasses amounting to 87% of the total observed (Table 2). This roughly corresponds with the relative abundance of the recorded food animals of griffons in the forest.

TABLE 2

CARCASSES OBSERVED IN THE GIR

	Domestic livestock				Wild animals			
Total	Water buffalo	Zebu cattle	Camel*	Horse	Chital	Nilgai	Sambar	Porcupine†
194	110	62	6	2	5	5	3	1
	88.7%		4.1%		7.2%			

* : Mortality among camels in the Gir is very low, but information is easily available.

† : One rarely comes across a dead porcupine in the Gir.

In the Serengeti the situation is different and the vultures obtain all the food supply from wild ungulates (Houston 1974). There are about 43,450 buffaloes and cattle, 450 camels and 40 horses grazing in the Gir every day (Joslin, pers. comm.) in addition to the 5684 chital, nilgai and sambar (Berwick, pers. comm.). Of the 43,450 buffaloes and cattle, about 24750 are resident, owned by maldharis from nesses, and by herdsmen from settlement villages. The rest belong to villagers outside the Gir forest but are brought inside every day for grazing. The camels and horses belong to the maldharis and herdsmen within the Gir. Additionally about 25,000 seasonal livestock (cattle and buffaloes) are grazed in the Gir (figure from Forest Dept. personnel) during the monsoon, from June to September.

Thus the Gir vultures draw their food from a total of about 49,600 heads of ungulates (domestic and wild) in the dry seasons, and from an additional 25,000 (domestic) during the monsoon.

But not all the carcasses are available for vultures to feed on. Of the 194 carcasses observed, seven were completely appropriated by lion or man (more information later) either at night or within a few hours after death and in any case before vultures had a chance to find the carcass. Vulture visits to the remaining 187 carcasses were evidently controlled by three major factors : (i) visibility of carcasses from the sky, (ii) vulture take-off space, and (iii) safety from predators.

Take-off space includes the ground space as well as the immediate air space. Although most of the griffons are able to get off the ground after three or four hops it is not possible for them to fly upwards through narrow openings or at a steep angle. Therefore when a carcass is vaulted over by low densely branched vegetation or when it lies among closely-spaced trees, vultures have to avoid them. Out of the 139 cases where all the three factors were favourable, vultures failed to come only in 15 cases. But when one or more of these factors was in the negative (n48) vultures did not come down to feed at all (Table 3). At times when the carcass was visible from the sky, but either the take-off space or safety from enemies was inadequate (e.g., lion guarding the kill) vultures did arrive at the area but they merely perched in near-by trees and never came down except for once when they soon left hurriedly.

The non-arrival of vultures at a carcass obstructed from view from above, could be attributed to their not having spotted it. But a different explanation is necessary for their not coming down when the view is clear but the take off space insufficient. It may be that vultures would rather prefer to miss a meal than risk being surprised by an enemy in such a situation. *At least on two occasions lions killed vultures which came too close, as also observed by Schaller (1972) in the Serengeti.

(b) *Seasonal variation in the food supply*

The food supply of griffon vultures through different seasons depends on two major variables namely,

(i) Density of vegetation : The extent of visibility of carcasses from above and the nature of take-off space are the major factors responsible for keeping vultures off carcasses or otherwise (Table 3). These two factors are mostly controlled by the density of vegetation, which varies seasonally ; hence carcass accessibility is minimal (33%) in the monsoon when the forest is dense and visibility and take-off space considerably reduced. Later on most of the trees, being deciduous become bare and the undergrowth disappears except for evergreen plants like *Carissa carandas*, when the carcass accessibility to vultures become 59% of the existing carcasses.

(ii) Abundance of carcasses : An increase in the number of carcasses would proportionately swell the number of carcasses

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* At the remains of lion show baits.

TABLE 3

FACTORS AFFECTING VULTURE VISITS TO CARCASSES

Number of cases		View from the sky	Take-off space	Safety	Vulture visit
48 :	11	0	×	×	0
:	13	×	×	0	0
:	8	0	0	×	0
:	10	×	0	×	0
:	3	0	0	0	0
:	2	0	×	0	0
:	1	×	0	0	0
139 :	15	×	×	×	0
:	124	×	×	×	×

× present. 0 absent.

accessible to vultures. Mortality rate of livestock, as recorded at nesses is higher during the monsoon (Table 4). In addition to this increase the availability of carcasses is presumably further augmented by the 25,000 seasonal livestock staying in the Gir during the monsoon. Thus, although the density of vegetation is the maximum in the monsoon, the increased number of deaths during this season ensures a satisfactory supply of food for the griffons (see further).

Frequency of Feeding :

The total number of livestock dying per day was estimated by recording deaths of buffaloes and cattle at six nesses for ten successive months and on this basis calculating deaths for the entire Gir. The number of deaths for the seasonal cattle was estimated approximately for the period of their stay in the Gir and added to the total. For daily visiting outside livestock, mortality due to predation only was estimated since these animals are normally not expected to die of illness while grazing inside, but only from predation or accidents, the former being the chief cause. Thus the average mortality of livestock for the monsoon is 27.32 per day and for the dry seasons (winter and summer) 11.8. Since accessibility to vultures is 33% for the monsoon and 59% for the dry seasons

TABLE 4

MORTALITY RATE (%) OF A SAMPLE POPULATION OF 955 BUFFALOES AND CATTLE AT 6 NESSES, FROM AUG. 1971 TO MAY 1972

Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
1.05	2.32	1.08	0.98	2.28	0.43	1.41	0.98	0.54	0.54
1.68		1.03							

the actual number of carcasses expected to be visited by vultures per day is 9 for the monsoon and 7 for the dry seasons. Mortality rate of camels is very low in the Gir and hence excluded from the estimate. Since horses were not more than 40 in all, these too were excluded.

The above figures do not include carcasses from the 5,684 wild ungulates. Using the average mortality rate of the resident livestock (since figures for the wild ungulates are not available for the Gir) and the vulture accessibility for the dry seasons and the monsoon, the number of carcasses of wild ungulates available for vulture would be 1.3 per day in the dry seasons, and 0.7 in the monsoon. Adding these figures to the livestock carcasses accessible to vultures, we get 8.3 per day for the dry seasons, and 9.7 for the monsoon.

Approximately 440 griffons were estimated to be present on any one day within the Gir Sanctuary during the study period (Grubh 1974). For this many birds 8.3 and 9.7 carcasses per day seem to be surplus as their minimum daily requirement of meat does not exceed 400 gm a day per bird (op. cit.). However, it is unlikely that all the birds attending on a carcass would always get a cropful of meat because (i) in lion kills abandoned by lions on their own, very little meat is left over for vultures (see further) and (ii) unopened and unskinned carcasses of adult-sized cattle and buffaloes cannot be fully appropriated by vultures (see further). Therefore the food supply in the Gir is assumed to be sufficient or else the birds do have the option of finding food outside the Gir.

In addition to the food supply discussed above, vultures also benefit from the remains of carcasses of buffaloes fed as bait to lions by the Forest Department for its ‘ lion shows ’. But the officials take care to see that only lions consume the meat and hence this food source is negligible for the vultures.

Utilization of Carcasses :

Upto 210 griffons have been noticed at a time at a single carcass in the Gir. The average number of griffons visiting any one carcass in the dry seasons was 55 (Grubh 1974). Among the vultures in the Gir which also includes the King *Torgos calvus* and the Neophron *Neophron percnopterus* it is the griffons that are responsible for the complete consumption of soft tissues and meat from large ungulates.

A carcass unless opened up by animals or man is difficult for griffons to tackle especially when it is fresh and of full grown large ungulates such as buffaloes and cattle (as also observed by Attwell 1963 ; Houston 1974). In such cases they scoop out meat through existing natural openings of mouth, anus, and genital regions. Also areas having softer skin such as the udder afford additional spots to work in. Through an opening wide enough for the head to go in griffons can scoop out meat from an area of at least 30 cm depth and 30 cm width by progressively pushing the long and bare neck (32 to 38 cm long) into the carcass. After repeated attempts the holes in the rear in large carcasses become wide enough for the whole bird to get into the body cavity. One of my whitebacked griffons for captive experiments was actually caught from inside the body of a dead bullock !

In this way the vultures consume most of the meat except from the neck, shoulder region, forelegs, and lower regions of hind legs. But this is a laborious process, and it takes more than a day to reduce a buffalo carcass to this level. Often the scorching sun dries up the hide and makes it difficult for vultures to fully consume such carcasses. A camel carcass when intact is particularly difficult to feed on.

However, carcasses are often available to vultures already partly or fully opened up, immediately or overnight, by scavenging animals and predators such as leopard, hyena, jackal, and the lion, or by humans. Maldharis believe that the leopard is the major scavenger among mammals in the Gir. Schaller (1972), Houston (1974) and others have found that all carnivores are also scavengers.

Vultures consume such preopened carcasses swiftly and more thoroughly. Consumption is faster and complete when hide has been removed. About 150 vultures were once noted to finish off the skinned carcass of an adult bullock (*c.* 300 kg) in 30 minutes. Similar observations have been made by T. R. Bell (Sálim Ali & Ripley 1968), Sálim Ali (op. cit.) and Houston (1974).

Mode of Feeding, and Behaviour at the Feeding Site :

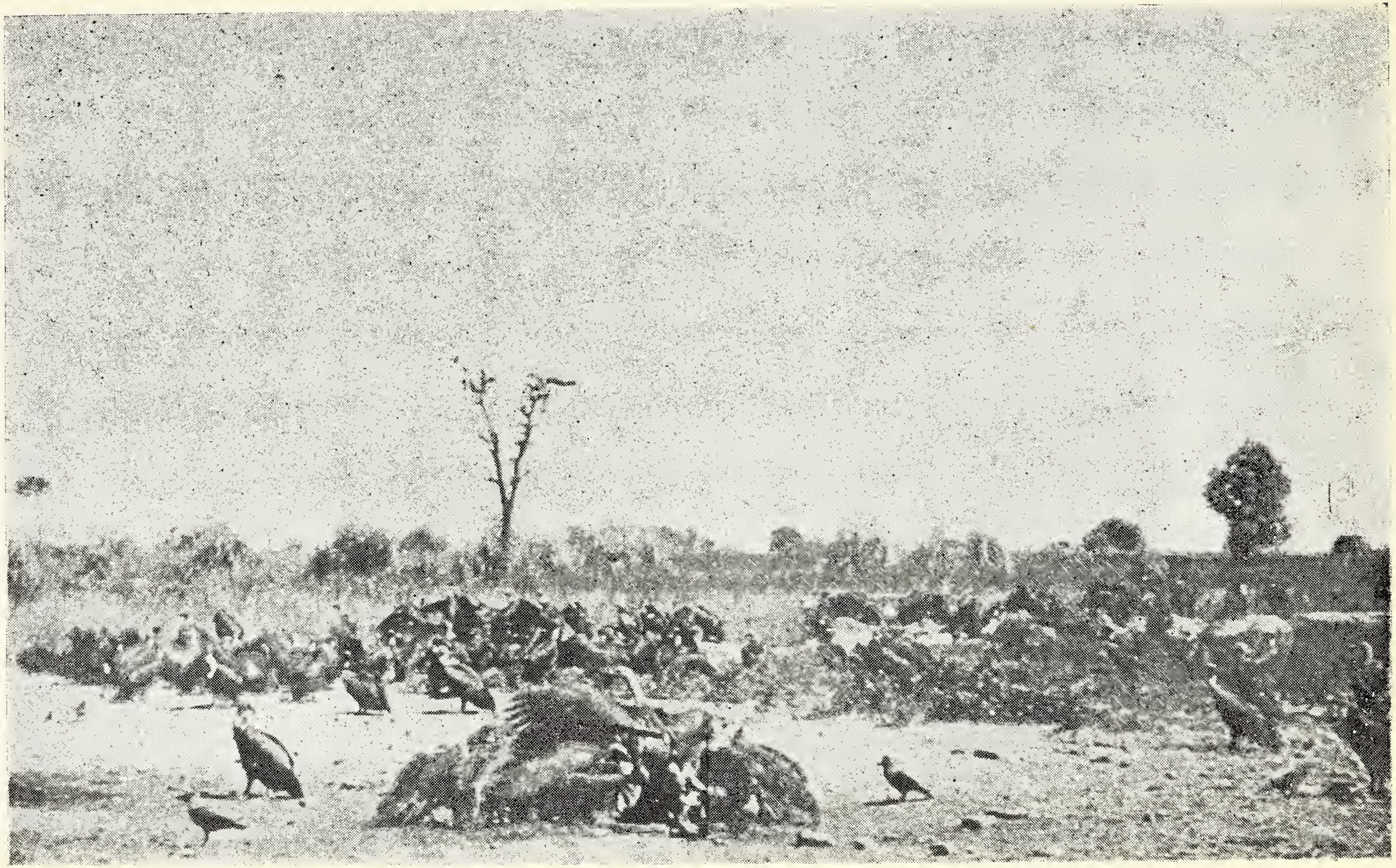
When a carcass is intact or is slightly opened up only a few dominant individuals feed at a time while the rest of the vultures will look on. However, when the carcass is opened wide enough, or the hide removed, all the birds crowd together and feed avidly. But within two to five minutes after this scramble, about one-fourth of the total gathering walk away from the carcass (Plate) and sit on a ledge half way up a slope or on any raised surface if available. Some of these birds return to feed while more and more walk away from the feast and sit on any raised ground near by including boulders and rocks. This behaviour was observed in every instance when mode of feeding was closely watched. This could be explained as follows : The birds wish to get to a safer place from where it would be possible to look out for approach of enemies, and from where it would be easier to take off if necessary. It is possible that once the initial hunger drive is mollified, the fear drive dominates and urges the birds to get to a safer place. Parallel behaviour has been recorded in the male chaffinch *Fringilla coelebs* after mating (Marler 1956). That some of the birds return to the carcass for a second round of feeding could be caused by the hunger drive dominating the fear drive once again. The presumable biological significance of this behaviour is (i) safety from enemies : vultures being slow to take off from the ground, are vulnerable to ground enemies such as the lion and the leopard. Therefore the shorter the time they spend engrossed in feeding, the lesser would be their exposure to a possible surprise attack ; (ii) by moving away from the food before getting fully gorged at the initial session, the bolder first comers unwittingly offer a chance to the less dominant individuals and the late-comers to feed.

While thus sitting away from the carcass, some birds go for a sip of water or even a bath if a stream or river flows by. After the bath they return to the slope and dry themselves with outstretched wings (also observed elsewhere by Attwell 1963). But this spread out posture was also commonly noticed in others which had not had a bath.

Another group behaviour noticed was, when sandy soil was available near by, some of the birds, already satiated, would hold their wings open, drop on their shanks, drag the body a few inches forward and flatten out with head, breast and out spread wings resting on the ground or raised slightly above it. This behaviour has not been reported by others although such a scene is depicted in one of Peterson's illustrations (1968).

As the food gets depleted through continuous feeding by so many birds, those that have already had their fill and been merely sitting around will take off together when a favourable gust of wind comes. Sometimes a false alarm from attending crows is enough to send them flying. On such occasions even some of the feeding birds may take off ; but they will soon return to resume feeding, whereas the gorged ones will spiral up and vanish into the sky.

When a carcass is not fully demolished before dusk, many of the vultures will settle on trees,



Vultures at a carcass.

chiefly *Ficus* spp., *Sterculia urens,* and *Boswellia serrata*, anywhere in the vicinity and spend the night there. On rare occasions when a carcass is in the open and there is a bright moon, some vultures will continue to feed even at night. This behaviour has also been observed by others in the Gir and elsewhere (Brook Fox 1922; Livesey 1939).

Next morning well before sunrise the birds that had left for the night will start heading towards the carcass, mostly flap-flying, skimming the trees. They will first settle on adjacent trees and presently descend on to the carcass.

Sometimes vultures come down to feed at dawn even when none had visited the carcass previously provided the carcass was available on that spot late in the afternoon of the previous day or earlier. Most probably they had noticed such carcasses on the same day, but being either too late for the day, or already satiated, they had roosted somewhere near by and come the following morning directly to the carcass. When carcasses were produced in the early morning, however, vultures arrived about three to four hours after sunrise. This can be explained by the fact that vultures start their forage flights only about 2½ hrs after sunrise (Pennycuick 1972; Grubh 1974). The majority of Houston's (1974) observations on griffons feeding off carcasses in the Serengeti were shortly after dawn. My own observations in the Gir do suggest that most of the carcasses observed by him must have been there the previous afternoon/evening itself and had been noticed by the vultures then. Thermal lift, a prerequisite for forage flights, is not normally strong enough to sustain vultures, especially in the Serengeti until 0830 hrs—that is about 2½ hrs after sunrise (Pennycuick 1972). Hence it is difficult for the birds to search and locate carcasses so early in the morning unless they had seen it on the previous day.

Association with the Lion :

Of the 97 lion kills studied, about 92% were of livestock, and only 8% belonged to the wild species (Table 5). This roughly corresponds with the relative abundance of the wild prey species and the domestic livestock.

TABLE 5

BREAK-UP OF LION KILLS (n 97)

Domestic livestock		Wild prey species	
Buffaloes & Cattle	Other	Nilgai	Sambar
88	1	5	3
(91%)	(1%)	(8%)	

During the study it became evident that the extent of consumption of lion kills by vultures was significantly altered by interference from a group of socially lowly-placed people who collect animal hides for sale and remove meat from carcasses for food. At times the cattle owners too, out of sentiment, prevent the predator from getting at the kill. Therefore, to obtain a realistic picture, the data obtained from kills not visited by man—referred to further on as 'kills under natural conditions' has been dealt with separately from the data from kills visited by man.

Of the total 97 lion kills, man had interfered with 27 kills and the rest left under natural conditions.

Use of lion kills under natural conditions :

Whenever a lion (or lions) made a kill it would either start eating the prey on the spot or drag it away and hide it under some thick cover, often under *Carissa carandas* (Table 6)—an evergreen bush (Apocynacea) affording privacy as well as protection from sun and rain.

While the kills hidden under dense cover are often not continuously guarded by lions,

TABLE 6

COVER PREFERENCE OF THE LION TO HIDE ITS KILLS

Number of kills hidden	Plant species where kills were hidden from overhead view				
	Carissa	Teak	*Acacia*	*Helicteres*	Mixed species
17	6	2	1	1	7

kills lying in the open are kept under close watch by them till they abandon the remains. Attwell (1963) found the guard duty of Kafue Park lions (N. Rhodesia) to be very effective.

In the Serengeti, the lion has to keep a very close watch to save its kills from scavengers such as the spotted hyena *Crocuta crocuta* and jackals (*Canis* spp.) (Schaller 1972). But in the Gir there is very little interference from such scavenging animals. The jackal *C. aureus* and striped hyena *Hyena hyena*, are uncommon in the Gir. In only two instances did a hyena effectively share a lion's kill. Other animals sharing lion's kills are mongooses (*Herpestes* spp.), crows (*Corvus splendens* and *C. macrorhynchos*), crested hawk eagle *Spizaetus cirrhatus*, tree pie *Dendrocitta vagabunda*, and different species of vultures discussed earlier. The leopard is rare at lion kills. Of all the scavengers it is the 3 species of griffons that benefit most from such kills. Houston (1974) observes that vultures are superior to mammalian scavengers specially because of their ability to scan vast areas. However, they do not feed off the kills until abandoned by the lion. Vultures also have the limitation of not being able to appropriate a carcass if it is hidden from view as discussed earlier.

Consequently the lion gets the most of its kills under natural conditions. As much as 73% of the meat from lion kills under natural conditions was observed to be consumed by the lion itself, and only 9% went to the vultures (Table 7). The above account also shows that the Gir vultures do not in any way compete with the Gir lion under natural conditions. Even at Serengeti, with so many more scavengers around, the lion is able to consume a major portion of its kills (Schaller 1972). There too vultures approach kills only when the lion is well away (op. cit.).

As for the lion competing with vultures, being itself an occasional scavenger in the Gir as elsewhere (Kruuk 1967 ; Goodall 1970 ; Schaller 1972 ; Houston 1974) the lion at times spots a carcass by following vulture movement which is probably a behaviour acquired through associating vultures with carcasses. In the Serengeti as much as 12% of the lion's food comes from self-dead carcasses which could have possibly formed food for vultures. In the Gir the lion scavenging upon carcasses is only occasional and is not significant.

Use of Lion Kills Under Human Influence :

Of the 26 kills interfered with by man 21 were visited by hide collectors. Maldharis chased away lions from the remaining six kills. The extent of meat use of kills was recorded for all the 21 kills visited by hide collectors and for one of the kills influenced by maldharis.

Although most of the hide collectors do not reside inside the sanctuary they do manage to visit carcasses in many parts of the forest. When the extent of consumption of meat by the lion and vultures from the 22 kills was assessed, it was found that the lion got only as little as 26%, whereas the hide collectors took away

TABLE 7

USE OF KILLS UNDER NATURAL CONDITIONS

Total kills	Kills visited by vultures	Approximate percentage of consumption		
		by lion	by vultures	remains *
63	20	73	9	18

* Meat unused and putrefied or used up by scavengers other than vultures.

48% and vultures 19% of the meat (Table 8). It is seen that the percentage of meat consumed by vultures from kills visited by man was twice as much as from kills under natural conditions.

The following are probably the chief points explaining this difference : As discussed earlier, griffons do not come down to feed if any one or more of the three factors are unfavourable namely, immediate safety, take-off space, and visibility. Also normally the lion guards its kills till fully fed, or hides it under dense cover. But when the hide collectors come on the scene they influence the situation at least in three different ways : (i) They scare away the lion from the site, thereby indirectly assuring safety for the vultures, (ii) they shift the kill to opener areas to conveniently work upon it which enables the birds to spot the food as well as land and take off with ease. Vultures visited 68% of the kills visited by man but only 32% of those left under natural conditions, (iii) the men skin the carcass, and often also remove some meat. Griffon vultures are able to clean up skinned carcasses within minutes.

The observations point to the conclusion that competition for food between the lion and the griffon vultures is rather insignificant in the Gir just as in the African forests. But here the situation changes drastically when man competes with the lion, and the vultures, together with man, take a considerable portion of the lion's legitimate food.*

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* Since then the Gujarat Forest Department has taken steps to keep away hide collectors from lion kills.

TABLE 8

USE OF KILLS INTERFERED WITH BY MAN

Total kills	Kills visited by vultures	Approximate consumption by			Remains *
		Lion	Man	Vultures	
22	15	26%	48%	19%	7%

* Meat unused & putrefied or used up by known & unknown scavengers.

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THE ECOLOGY AND BEHAVIOUR OF THE INDIAN PEAFOWL (*PAVO CRISTATUS*) LINN. OF INJAR

A. J. T. JOHNSINGH AND S. MURALI[1]

(*With a text-figure*)

INTRODUCTION

The distribution of the Peafowl *Pavo cristatus* (Linn.) in India is patchy but it ranges from the Himalayas to the southernmost districts. In Tamil Nadu a fairly large population of the peafowl is seen in Ramanathapuram and Madurai districts. The survival of the peafowl in these two districts is enabled by the presence of suitable habitat in some parts in the form of scrub jungle for breeding, trees to roost, fields for foraging and above all the protection afforded by the religious sentiment of the people. In other areas where the peafowl occurs it is much persecuted for making the 'peacock oil' of supposedly medicinal value. It being a large ground-nesting bird and obtaining food at least partly from the cultivated fields, its population growth is liable to be influenced by the activities of man, and his animals like village dogs. The present study of the general ecology and behaviour of the peafowl of this area was undertaken by us with a view to develop measures for its conservation.

HABITAT DESCRIPTION

The study was carried out in Injar, a small hamlet situated 6 km west of Sivakasi, in Tamil Nadu. The hamlet is divided into Meloor (upper village) and Keeloor (lower village) by a sandy water course and fields. The human population, averaging about 1,200, is entirely Hindu. Injar is locally well known for its Aladi Easwaran temple and an old big banian tree (*Ficus bengalensis*). This and four other banian trees which stand 200 metres north of the temple are the roosting places for a good population of peafowl which form an added attraction in this village.

On the southern side of the village stretching east to west there is a big rain fed pond. The southern part of the pond is planted with *Acacia arabica* by the Tamilnadu Forest Department. The total cultivable land of the village is around 100 hectares and this is surrounded by fallow-land. The common flora and fauna of the area which could have some impact on the peafowl population are listed in Table I.

STUDY METHODS

The study was started from September 1975 and continued till the end of March 1976. The study period could be divided into a short pre-breeding period (September) a breeding period (October, November and December) and a post-breeding period (January, February and March). During the reproductive period the observations were scarce as one of the observers (Johnsingh) was away from 10 October 1975 to 20 December 1975. Altogether we visited the area 14 times—10 times for total counting as well as for observation and 4 times for observation alone, spending 2 to 3 hours at a time in

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TABLE I

FLORA AND FAUNA OF THE STUDY AREA

FLORA

S. No.	Family	Scientific name	Remarks
	TREES AND SHRUBS		
1.	Family Rhamnaceae	*Zizyphus jujuba*	× □
2.	Family Mimosae	*Acacia arabica*	* 0
3.	,,	*Prosopis juliflora*	□
4.	Family Cactaceae	*Opuntia dillenii*	× ?
5.	Family Rubiaceae	*Morinda tinctoria*	× ? □
6.	Family Salvadoraceae	*Azima tetracantha*	= □
7.	Family Euphorbiaceae	*Fluggea leucopyrus*	□
8.	,,	*Euphorbia antiquorum*	□
9.	Family Moraceae	*Ficus bengalensis*	× 0
	HERBS		
10.	Family Umbelliferae	*Centella asiatica*	=
11.	Family Amarantaceae	*Digera arvensis*	=
12.	,,	*Amarantus viridis*	= ?
13.	Family Euphorbiaceae	*Croton sparsiflorus*	×
	GRASSES & SEDGES		
14.	Family Cyperaceae	*Cyperus rotundus*	▽ ?
15.	,,	*Cyperus bulbosus*	▽
16.	Family Graminae	*Echinochloa colona*	*
17.	,,	*Panicum repense*	*
	CROP PLANTS		
18.	Family Papilionaceae	*Arachis hypogaea*	*
19.	Family Solanaceae	*Capsicum frutescens*	×
20.	,,	*Lycopersicum esculentum*	×
21.	Family Musaceae	*Musa paradisiaca*	= × △
22.	Family Liliaceae	*Allium cepa*	=
23.	Family Gramineae	*Oryza sativa*	×
24.	,,	*Saccharum officinale*	□

0	Roosting site	=	Leaf eaten
□	Brooding site	▽	Rhizome eaten
*	Seed eaten	△	Flower eaten
?	Uncertain	×	Fruit eaten

VERTEBRATE FAUNA

S. No.	Common Name	Scientific name	Remarks
	REPTILES		
1.	Fan throated lizard	*Sitana ponticeriana*	×
2.	Garden lizard	*Calotes versicolor*	×
3.	Rat snake	*Ptyas mucosus*	Young ones may be eaten.
4.	Saw scaled Viper	*Echis carinata*	?
5.	Russell's Viper	*Vipera russelli*	?
6.	Cobra	*Naja naja*	?
	BIRDS		
7.	Cattle Egret	*Bubulcus ibis*	=
8.	Pond Heron	*Ardeola grayii*	0 = ?
9.	Black Ibis	*Pseudibis papillosa*	0
10.	Common Pariah Kite	*Milvus migrans*	* ?
11.	Brahminy kite	*Haliastur indus*	*
12.	Spotted Owlet	*Athene brama*	0
13.	Indian Roller	*Coracias benghalensis*	=
14.	Small green Bee-eater	*Merops orientalis*	=
15.	Black Drongo	*Dicrurus adsimilis*	=
16.	Common Myna	*Acridotheres tristis*	0 =
	MAMMALS		
17.	Common Mongoose	*Herpestes edwardsi*	*
18.	Jungle Cat	*Felis chaus*	*

0 shares the roosting site.
= competes for insect food.
× eaten.
* Predator on chicks.
? Relationship uncertain.

the field. Besides, we also spent two nights under the Aladi Easwaran temple banian tree, listening to and recording the calls of the peafowls. The crop content of three birds which were available was analysed for the food types of the peafowl. Plants found in the crops were identified with the help of the Botanical Survey of India, Coimbatore. Rainfall data for the duration of the study was obtained from the Cotton Research Station, Srivilliputhur, situated 13 km to the west of Injar.

For counting the peafowl, we followed the total counts method (Odum 1971), counting the peafowl as they came to roost. Gaston (1975) has advised counting them on moon lit nights while the birds are roosting high up on tall trees, against the background of a bright sky. But this method was of no use at Injar since the peafowl were indistinguishable from the dense foliage of banian trees. Since the peafowl of the area were not shy of human beings the counting yielded a reasonably accurate number of their population. Peafowls were classified into t males (males with train), males, females and chicks. Females were differentiated from immature males by the presence of white breast and the absence of chestnut primaries.

RESULTS AND DISCUSSION

Population Studies :

The number of birds counted and the percentage of t males, males, hens and chicks are given in Table II. Table II indicates the status of the population throughout the period of study. From this data it is possible to infer the following: (*a*) There was a gradual reduction in the number of females between 9 September 1975 (75 females) and 21 December 1975 (31 females) and an obvious increase on 24 March 1976 (134 females). This may indicate that the peahens had migrated to favourable breeding grounds during the breeding season. Probably the migration started even before the beginning of the breeding season as at the commencement of the study there were only 75 females and at the end 134. (*b*) The increase in the male population probably suggests that the males also returned to the study area from the breeding grounds. (*c*) It could be seen that the ratio of the adult males and females (47 : 100) at Injar is completely different from the sex ratio observed by Sharma (1972) at Jodhpur (170-210 ♂♂ : 100 ♀♀). Further the sex ratio of eggs 60% ♂♂ and 40% ♀♀ observed by Sharma (1972) also does not seem to correlate with the adult birds at Injar. Presumably this disparity may also be due to our inability to distinguish the immature males from the adult females in the failing light. (*d*) By comparing the data of 7 October 1975 (a probable date around which active brooding commenced at Injar during the present study) and 28 February 1976 (the date on which maximum number of chicks were counted) it could be seen that the approximate population of breeding females formed 31% of the peahen population. The fact that a population of nearly 42 breeding females had 80 chicks with them shows an approximate birth rate of 1 : 2.

TABLE II

SEX AND AGE CLASSES OF PEAFOWL COUNTED

Visit No.	Date	Female	Chick	Male	t. Male	Total	% of Female	% of Male	% of Chick	% of t. Male	Aver. rainfall cm.
1.	9.9.75	75	—	18	27	120	62.5	15	—	22.5	5.5
2	11.9.75	70	—	21	17	108	64.8	19.4	—	15.7	5.5
3	28.9.75	48	—	17	23	88	54.5	19.3	—	26.1	5.5
4	7.10.75	50	—	17	28	95	52.6	17.9	—	29.5	0.9
5	12.10.75	47	—	28	28	103	45.6	27.2	—	27.2	0.9
6	26.10.75	53	—	34	15	102	52	33	—	15	0.9
7	21.12.75	31	1	40	13	85	36.5	47	1.2	15.3	0.1
8	18.1.76	44	4	77	6	131	33.6	58.7	3	4.6	Nil
9	28.2.76	92	80	63	10	245	37.5	25.7	32.6	4	Nil
10	24.3.76	134	64	35	28	261	51.3	13.4	24.5	10.7	Nil

Studies on the droves :

Ali (1972) while discussing the organisation of the droves has stated that the male is polygamous and is often accompanied by 4 to 5 hens. But seasonally the sexes wander separately. We observed : (*a*) The harem formation by the t males was more common in the month of October, (*b*) the first batch of chicks was seen on 21 December 1975, (*c*) the maximum appearance of chicks was noted on 24 March 1976, (*d*) at the end of the breeding season and especially after the formation of the flocks of mother and chicks there was no clear cut formation of droves and the sexes began to wander separately.

Feeding :

Peafowls at Injar were found close to cultivation. In places like the Sigur Reserve Forest and the Bandipur Tiger Reserve they live far away from cultivated fields (Johnsingh, unpublished). This shows that the peafowls can thrive on cultivated crops as well as on wild vegetation. They are omnivorous. Seeds, grains, lentils, groundnuts, tender shoots of crops, flower buds, berries and drupes (e.g. *Carissa*, *Lantana*, *Zizyphus*), wild figs (*Ficus glomerata* and other species), centipedes, scorpions, lizards, small snakes (one 20 cm long), insects (e.g. grasshoppers, beetles, grubs, caterpillars) and worms have all been more or less regularly found in crops and gizzards. In and around villages they also feed upon human excreta (Ali and Ripley 1969). At Injar the peafowls feed in the cultivated fields, in the neighbouring *Acacia arabica* plantation and in the surrounding fallow lands. According to Ali and Ripley (1969) in areas where the peafowl is semi-feral, and abundant, it is highly destructive to cereal and groundnut crops. We observed them to feed on paddy, chilly, groundnut, tomato and to a small extent on banana, of the 452 banana bunches checked, however, only seven were damaged by the peafowls. The villagers reported that there were usually more damage when two or three peafowl alighted on a banana plant having a mature bunch, the sudden impact resulting in the trunk giving way. Bunches brought down thus were later damaged by the peafowl.

Analysis of the crop content of the 3 birds showed that the peafowl are mostly primary consumers. This food habit may be influenced by the availability of animal food. Crop analysis showed that one bird had mainly eaten the seeds of the grasses *Echinochloa colona* and *Panicum repense*. Another had eaten the leaves of plants such as *Digera arvensis*, *Centella asiatica*, *Amaranthus viridis* (?), *Allium cepa* and a flower of *Musa paradisiaca*. The animals eaten were one short-horned grasshopper and two termites (*Acanthoptermes* sp.). The third bird had eaten 12 ripe chillies, paddy, a fruit of *Croton sparsiflorus*, one seed of *Acacia arabica* and rhizomes of *Cyperus rotundus* (?), *Cyperus bulbosus*, two small black beetles and two ants (*Componotus compressus*). Once a mother and two chicks were seen feeding on the tender leaves of the thorny shrub *Azima tetracantha*.

Calls :

Different authors have described the calls of the peafowl differently. Ali (1972) described two calls—one a loud harsh screaming '*May-awe*' and the other, short gasping shrieks '*Ka-aan*', *Ka-aan* repeated rapidly 6-8 times with a pumping action of the head and neck. Scott (1964) has described two calls. One a loud *phi-ao-phi-ao* and the other a shrill *ka-oan-ka-oan*. To Baker and Inglis (1930) the loud cry of the peafowls sounded like *pehaun*, *pehaun*.

According to our observation the vocalizations of the peafowls, both adults and chicks, could be grouped into two types, the long calls and short calls. The long notes were easily inscribable but the short calls as their intonation and intensity had very little variation were difficult to record. The different calls made by the peafowl and the context in some cases are given in Table III. Following the classification of Nicholas Collias (in Peterson 1968), it is possible to sort the various calls of the peafowl into the five categories.

It can be seen (Table IV) that the vocal repertoire of peafowls, probably has more calls for flocking, group movements and for alarming the flock than for other activities. No wonder the development of these calls is essential in a socially cohesive large bird whose flight is restricted and dangers manifold.

On 6 October 1975, 12 days prior to the full moon, the night was dark. We reached the tree at 1915 hrs. and all calls were recorded till 0520 hrs. In all there were 105 calls. In contrast on 15 January 1976 being 3 days prior to full moon the night was fairly bright and there was complete silence from 1900 hrs. to 0615 hrs. Only at 0615 hrs. were there two alarm calls (*khok*, *khok*). Silence prevailed in spite of the screeching of the spotted owlets (*Athene brama*), the calls of the black ibis (*Pseudibis papillosa*) and the barking of dogs. Possibly the major reason for the peafowls for being more vocal on the night of 6 October 1975 was the incidence of active breeding season. We are unable to exactly account for their silence on the night of 15 January 1976. The bright moon light might have been a reason. It may also be due to the presence of chicks.

Breeding :

It appears that the display or dance of the cock is closely associated with the breeding season. During September dancing was seen 11 times and in October thrice. Nine times the t males danced alone, twice they danced before females and once a male danced before two on looking males. The observation of the t male dancing in front of 2 males could be interpreted as a form of dominance display. Scott (1964) also has seen a dozen peacocks dancing in the absence of peahens. Of the 50 times he had seen them dancing in the presence of peahens only twice did the peahens stop pecking or lift their head to see the cock. According to Ali and Ripley (1969) the hen usually appears completely unconcerned during all these amorous antics but she occasionally responds with an inferior imitation of the cock's movements.

During the period of five years of observation from 1967 to 1971 twenty-one sheddings of train feathers of peacocks (5 in 1967, 5 in 1968, 5 in 1969, 3 in 1970 and 3 in 1971) were observed (Acharjyo and Misra 1973). Out of these, 20 sheddings were observed in August and September whereas only one shedding was observed in October and November during the year 1969. From Table II it can be inferred that at Injar the t males started shedding their train at the end of October and most of the t males had completely lost their train by the middle of January. In the Bandipur Tiger Reserve, Karnataka, the t males started shedding their train by July end and almost all had lost their train by the end of October (Johnsingh, unpublished).

Good showers of rain are necessary for the successful commencement of the breeding season (Sharma 1972). Basing on the fact that only in the month of September the area had more rainfall from the north-east monsoon (Table II) it can be stated that the active breeding period of the peafowl at Injar started in September and continued upto October. This differs from what Ali and Ripley (1969) have recorded for southern India as the breeding season for peafowl (i.e. April and May). The peafowls of Jodhpur where Sharma (1972) made his observations bred in the months of June, July and August. Despite the seasonal differences in the commencement of the breeding seasons both our observation and that of Sharma hypothesize the need of a good rain for the successful beginning of the breeding season.

TABLE III

S. No.	CALLS—Long notes	Sex	Context (time)	Remarks
1.	May-awe, may-awe	Cock	Early mornings and evenings. Before and after roosting.	Commonly heard during the breeding season.
2.	Coo-Coo-Coo ...	Cock	While flying after being disturbed.	When disturbance was sudden either in the form of man or dogs. Social warning?
3.	Kayong—Kayong—Kayong	Cock	While in the company of peahens?	The head and neck were jerked violently while making this sound. Associated with dominance display?
4.	Kayone—Kayone—Kayone	Cock	On seeing light? or to answer the call from the 4 Banian trees. Response to the call from the neighbouring banian trees.	Alarm? or social contact.
5.	Kha Kha Kha ...	Mother hen	When flushed out to fly while hiding inside a thicket with two chicks.	A much agitated call.
6.	Gnang gnang gnang	Chick	While separated from the mother.	Call was repeated till it rejoined its mother or when it was disturbed by man or dog.
7.	Phthruu .... Phthruu	Cock	?/Heard in the night as well as in the morning.	?
8.	Short notes :/Khok	? Cock	On seeing a man carrying a lantern. After alighting on a tree after being chased by a dog.	Alarm Alarm
9.	Keyene	Cock Cock	In response to the call of the black ibis. When a dog barked from a distance of 200 metres	Alarm? Alarm
10.	Kirk	? Cock	?/Heard in the night. When it saw a hare running close by.	? Alarm
11.	Fhrang	Cock Mother hen with two chicks	When chased by a village dog. While alighting on a tree after being chased by a village dog.	Alarm Alarm

TABLE IV

The various sounds that birds make have been grouped by Nicholas Collias (as cited in Peterson 1968) into five main categories. The calls of the peafowl we had understood and classified under those five categories are as follows :—

S. No.	Categories	Calls of Peafowls
1.	Flocking and group movements	1, 2, 4
2.	Food	..
3.	Birds of prey and enemies	2(?), 5, 8, 11
4.	Parent young relationships	6
5.	Sexual behaviour and related aggression	3

In places where the peafowl is not held in reverence, it is a shy bird breeding well away from the haunts of man (Baker and Inglis, 1930). But at Injar, being protected by the local people, the peafowls do have the habit of laying eggs amidst paddy and sugar cane cultivation close to human habitations. Sharma (1972) reports of a peahen returning to a particular nesting site, protected by people, for three years consecutively.

While selecting the brooding site nearness of water is one of the prerequisites (Baker and Inglis 1930). But Sharma (1972) emphasises the need for the isolation and tranquility of the habitat more than the nearness of water. Restricted water availability at Injar and the often used brooding sites well away from the water source may support the view of Sharma.

Peahens have the habit of walking away with the chicks that are hatched in the first two days of hatching. Further, peahens are supposed to be incapable of looking after more chicks than five (Sharma 1972). But there is one observation of a mother peahen with six chicks at Injar during the present study. Also on 18 October 1975 Johnsingh had observed a peahen with six 2-3 month old chicks in the Sigur Reserve Forest. Perhaps these are exceptional cases. Because of early post hatching mortality (Figure 1), in most cases only one or two chicks accompanied the mother. Further the 20% reduction seen in the number of chicks, from 28 February 1975 to 24 March 1976 (Table II), also speaks for the rate of early mortality. Table I shows the probable predators of chicks.

Chicks below 30-45 days were rarely seen. Once when two one-month old chicks with their mother were sighted they took cover amidst the thorny *Azima tetracantha.* No amount of talking and walking around the bush could bring them out. The chicks were brought to the banian tree for roosting only when they were nearly two months old and were capable of flying well.

Behaviour of the Peafowl :

In contrast with other gallinaceous birds, peafowl, at Injar seem to bother little about maintaining their territories. In general, they were an amicable lot while feeding or assembling for roosting. The observation of Sharma (1972) that the mother hens are capable of chasing the chicks of other broods could not be corroborated with supporting evidence during this study. Throughout the study, nine interactions between different peafowl were seen. Of these, one

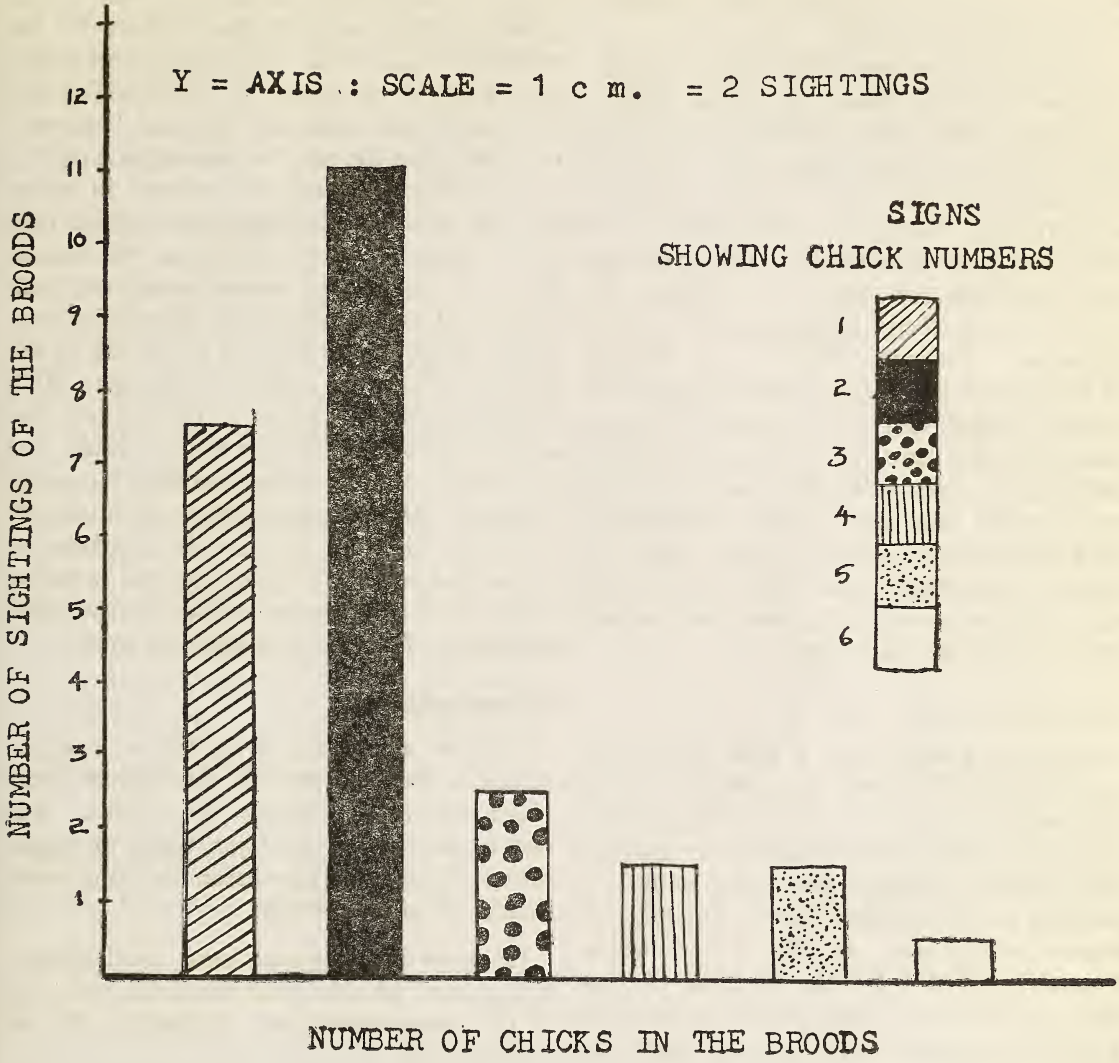

Fig. 1 Number of chicks in the broods seen and the number of sightings of the broods.

interaction was between a t male and a male, three between t males and males, one between a male and a female and one between a female and a mother hen with three chicks. The interactions were observed, they were either in the form of chasing, or rushing at, or pecking or mere challenging and never was seen the violence commonly seen in birds like the domestic fowls. On 7 October 1975 at 0700 hrs. three t males and one male went on pecking nearly for 3 minutes around a place and this was characterised by lack of fighting and show up of dominance. Thrice the birds were observed having dust bath. Of the seven birds observed, six were females and one was a male. Peafowl usually stood on rock heaps or hay stacks to bask in the morning sun, especially when the morning was cold.

A few interactions with other animal species were also observed. Nearly 9 months earlier in the same study area, Johnsingh (1976) had seen 2 peacocks teasing a large cobra. During this study once a black drongo (*Dicrurus adsimilis*) flew chasing an insect close to a mother hen with three chicks. This made the mother and the two nearly two months old chicks to raise their hackless and assume threatening postures. Twice we flushed out blacknaped hare (*Lepus nigricollis*). One ran into a flock and was charged by a male. When the other hare ran close by a male, it gave only an alarm call. The peafowl of the area were not wary of the local people but if any one in unusual attire, in pants and shirts passed by, they became alert and slowly moved away. Unless chased they were not unduly perturbed by the village dogs.

Local dangers :

Except for a female and a male which were seen limping, all others appeared to be in good health. The chief enemy of the peafowl in this area, as everywhere else, is man. Sharma (1972) mentions the damage that could be caused to the broods by children. Possibly this occurred at Injar also. In spite of the religious presumption that eyes will go blind if any harm was done to the eggs, there were instances of children breaking or cooking the eggs for food.

Only once did we come across a village dog eating a freshly killed t male in the forest plantation of *Acacia arabica*. Obviously, the overhanging thorny canopy could have incapacitated the flight and the escape of the cock. Though observed only once, the danger from dogs, which is reported by Sharma (1972) also, could be accounted as one of the chief factors detrimental to the peafowl population especially to the chicks. Most of the villagers, despite considerable damage to their crops, great heartedly accepted the presence of the peafowl in their land. If circumstances arose, they went to the extent of manhandling the poachers. Yet, poaching by local 'hunters' occurred when the peafowl fed on the outskirts of the village or when they roosted in places like the *Acacia arabica* plantation which they did in times of overcrowding at the banian trees. As far as our enquiry went, the local people did not attribute any aphrodisiac properties either to the flesh or to the leg of the peafowl unlike in Jodhpur (Sharma 1972). Another growing danger is the gradual disappearance of the suitable thorny shrub, that give safety to the brooding peahens, for use as firewood. During a year with good north-east monsoon, this factor may not be significant as the needed cover for laying eggs and brooding comes easily from several smaller thorny bushes that sprout fresh leaves during the rains.

Recommendations :

(1) It would be useful to have a total population study of peafowl throughout Tamil Nadu so as to assess its status. For this, at least areas like Injar, where an aggregation of peafowl has been seen for many years, should be given priority.

(2) After notifying such areas, local officials, colleges and schools could be asked to take part in the preservation and protection of our national bird.

(3) In Ramnad district some of the Hindus do not tolerate the presence of the peafowls in their arable lands. However, in certain villages like Injar the peafowl is spared local harassment. This trend should be encouraged and in order to make good the loss caused by the peafowl, a certain form of compensation could be provided to the farmers.

(4) In places like Injar, the destruction of the brooding sites, the major danger, should

be averted. For this, certain areas like the tank bed could be intensively planted with thorny shrub. The villagers should be directed to protect the brooding sites.

(5) At Injar a local man can be employed by the Forest Department to look after the peafowl and in turn he should have the privilege to collect and sell the moulted tail coverts. This will actively involve him in bettering the status of the peafowl in the area.

(6) To maintain a healthy population of peafowl, in times of over abundance, a considerable percentage of the total increment to the population may be netted and transported to other suitable habitats.

We wish to close with a plea to the authorities concerned to take steps needed to protect the peafowl and its habitat. The peafowl may not appear to be in imminent danger in the study area but its vulnerability to the growing pressures of man calls for a continued study and protection from poachers. Another cognisable factor is that if the peafowl are surviving in isolated pockets it is not because of its status as the national bird but because of religious sentiment. May be when sophistication eradicates the religious sentiment of the people concerned the peafowl will have no future. At any rate the urgent step that has to be taken to safeguard the future of the peafowl in places like Injar where the surrounding scrub is slowly disappearing before the unrelenting demand for firewood is to grow small patches of thorny thickets to give safety to the brooding peahens, and protect the existing scrub.

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ECOLOGICAL NOTES ON SOME MIGRANT WADERS IN INDIA

K. S. R. Krishna Raju[1]

(*With six graphs*)

The food and feeding ecology of some waders of the family Charadriidae on their wintering grounds were studied briefly at two locations in India and are reported here.

Study Areas :

The study was carried out at Bharatpur in eastern Rajasthan and at Point Calimere in Tamilnadu between October 1971 and March 1972.

Bharatpur Bird Sanctuary (27°13′N, 77°32′E) is the largest known breeding colony in India for many birds and a famous winter resort for migrant passerine and non-passerine birds.

It is a semidesert area, with characteristic vegetation such as *Acacia nilotica*, *Salvadora persica*, *S. oleoides* and *Capparis aphylla*. The average annual rainfall is about 63.5 cm and temperature 27°C. Its environs, chiefly the inundated fallow fields, marshland and jheels offer good feeding and resting ground for many species of birds including waders (Charadriidae). When water conditions are good (depending upon the monsoon) thousands of waders visit the area during the winter months. Most of the observations were made at places like Chiksana, Uncha and Nagla away from the Sanctuary.

Point Calimere Wildlife Sanctuary (10° 18′N, 79° 51′E) in Tamilnadu is approximately 26 sq. km of scrub jungle where thorn and xerophytic vegetation predominate. The mean annual temperature is 26.5°C and mean average rainfall 127 mm. Plant species like *Manilkara hexandra*, *Dichrostachys cinerea*, *Carissa carandas* and *Excoecaria agallocha* are common in the forest tract. The forest is intersected by numerous tidal inlets and creeks of varying size. The habitat can be described as marine littoral and coastal swamps.

The extensive salt swamps provide a gathering point for many migratory waders and an intermediate station for migrants that visit Sri Lanka. Observations at Point Calimere were made mainly at Ramarpadam, Muniappan yeri and other tidal and non-tidal areas.

METHODOLOGY

This study was made when I was working as a research assistant for the BNHS bird migration scheme. I utilised most of the ' non-ringing ' time for the purpose, since we normally worked in areas where the waders fed nearby. Full day field observations were made at one place or other during our rest days.

In all about 120 hours of observation were made as mentioned below, in addition to many hundreds of brief supporting observations.

Species Studied		Hours of observation Bharatpur	Point Calimere
Tringa glareola	..	6	8
Tringa totanus	..	—	16
Tringa ochropus	..	6	—
Tringa nebularia	..	—	2
Calidris minutus	..	10	40
Calidris temminckii	..	8	—
Calidris testaceus	..	—	2
Charadrius dubius	..	—	22
Total	..	30	90

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[1] Saileru Food Products (Pvt.) Ltd., Spoonbill House, Dasapalla Hills, Visakhapatnam-530 003. (A.P.)

Peck rates and daily routine of feeding :

By this I mean the average number of pecks a species made during a period of 5 mins. Though earlier workers like Goss-Custard (1969) and others, adopted the time taken on average for a given number of pecks.

During an hour or slightly less, 5-8 counts of 5 mins. duration were made on one or more birds of a species. As far as possible not less than 4 counts were made during an hour on a particular bird and at a particular place, and the average figures were taken as the peck rate for that species for that hour of the day. Observational data for a particular hour were also collected on different days, in different weather condition, and the figures were all added up to arrive at the overall average peck rate per five mins. for the species. Seasonal fluctuations of peck rates, though noted, were not quantified at this stage. There are many limitations and drawbacks in this method.

Cumulative observations covered practically all daylight hours, thereby giving some indication of the birds routine and behaviour.

Horizontal Distribution : This data was collected by following the method adopted by Recher (1966) since all the species are noted in the same area. I followed Thomas & Dartnell (1971) in recognizing five separate horizontal zones in tidal and non-tidal habitats. The areas were defined as : (1) Zone A, areas above the water's edge not retaining a surface film of water, (2) Zone B, areas of sand and mud above the water's edge retaining a surface film of water, (3) Zone C, the water's edge. Beyond the water's edge, (4) Zone D, the area between the water's edge and a line 0.5 m beyond and parallel to the water's edge, and (5) Zone E, the area beyond Zone D. Data from non-tidal areas were also collected on the same day for some species during the latter part of the study, along with the data from tidal areas, for the purpose of comparison. In non-tidal areas also, similar zonations were recognised as was done by Thomas & Dartnell (1971) ; where zone A corresponds to area of dry mud, Zone B to areas of wet mud, and the remaining three zones are as for the tidal areas. In this case also the distinction between Zone D and E was arbitrary, but was retained to find out the distributional differences.

OBSERVATIONS

Tringa glareola : Mostly seen in shallow (3-5 cm deep) water, picking or probing. Many attempted pecks were withdrawn half way. The hourwise peck rates were different between the populations of Bharatpur and Point Calimere (Table 2). The birds of Bharatpur (BHPR) seemed to be more gregarious than those at Point Calimere (PTC). They were seen more often singly at PTC than at BHPR. BHPR population was found oftener in association with other species than that at PTC (Table 1). They gave head ' bobs ' invariably on alighting but the bobs were not seen while feeding as in *T. totanus.*

Charadrius dubius : They usually picked up titbits near the water's edge, and rarely in the water (graph 6) and were never seen probing. Very fast on foot and every peck was followed at least by a foot movement and they did not pick up twice from any single point. Picking up something, walking swiftly, stopping suddenly and picking up again . . . . this ritual goes on almost endlessly.

C. dubius feeds in association with other waders. Their flocking pattern and other details are evident from the Table 1.

From the feeding routine and peck rates they appear to be more active during early hours, again at mid-day and at dusk (Graph 2).

Tringa ochropus : Seen feeding in ' knee ' (birds knee !) deep water, often alone along the water's edge, walking swiftly and picking up

TABLE 1

FLOCK COMPOSITION AND FEEDING ASSOCIATIONS

Species	Station	No. of times the species was seen singly or in groups of —and percentage																With others	%	Total No. of observations
		(1) Singly	%	2	%	3-5	%	6-10	%	11-25	%	26-50	%	51-100	%	100-more	%			
Calidris minutus	Point Calimere	2	7.40	2	7.40	3	11.1	4	14.8	1	3.7	4	14.8	3	11.1	3	11.1	5	18.50	27
Calidris minutus	Bharatpur ..	3	33.3	2	16.66	1	8.38	—	—	—	—	—	—	—	—	—	—	5	41.6	12
Tringa totanus	-do- ..	1	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	80	5
Tringa totanus	Point Calimere	4	40	2	20	2	20	—	—	—	—	—	—	—	—	—	—	2	20	10
Tringa glareola	Bharatpur	23	49.91	3	6.51	1	2.17	2	4.34	1	2.17	—	—	1	2.17	—	—	15	32.55	46
Tringa glareola	Point Calimere	6	60	1	10	1	10	—	—	—	—	—	—	—	—	—	—	2	20	10
T. nebularia	-do- ..	4	44.44	2	22.22	2	22.22	—	—	—	—	—	—	—	—	—	—	1	11.1	9
Tringa terek	-do- ..	4	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	20	5
Calidris temminckii	Bharatpur ..	4	44.44	1	11.1	1	11.1											3	33.33	9
Charadrius dubius	Point Calimere	5	18.50	5	18.50	4	14.8	2	7.4	2	7.4	1	3.7	—	—	3	11.1	5	18.50	27

TABLE 2

PECK RATES—NO. OF PECKS PER 5 MINUTES ON AVERAGE FOR EVERY HOUR BASED ON DATA COLLECTED ON SEVERAL DAYS

Species	Place	HOURS												Total daily average for entire period
		06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	
Tringa glareola	Bharatpur ..	—	—	126	104	76	80	75	106	116	—	—	26	85
Tringa glareola	Point Calimere ..	70	107	64	—	—	110	—	—	—	66	—	—	83
Tringa totanus	,, ,, ..	150	167	104	—	—	104	—	—	166	—	—	163	142
Tringa ochropus	Bharatpur ..	—	—	83	90	88	92	76	60	21	18	82	65	67.5
Calidris minutus	Point Calimere ..	120	140	106	131	88	155	52	68	74	65	98	98	100
,, ,,	Bharatpur ..	—	—	—	113	120	133	128	103	87	32	68	92	97
C. temminckii	-do- ..							130	120	76	40	—	69	87
Ch. dubius	Point Calimere ..	124	107	86	110	—	96	—	70	—	30	67	107	—

here and there. Foot work is faster than the peck rates. Data on flock composition and peck rates are given in the Tables 1 and 2. It appears to be less gregarious, but does not hesitate to feed in association with other waders.

Calidris minutus: These sociable little waders often feed in large flocks—the biggest I saw was about 5,000 birds at Point Calimere. Rarely seen feeding singly. Small groups of 20-30 were not un-common and it readily mixes with other waders. Mostly seen feeding by picking rather than by probing (not exclusively) and generally feeds on the shore line. (Horizontal distributional data are given in graph 6). Feeding rate appears to be higher, though peck success data was not collected. Only the peck rates were recorded (Table 2). However, the rate of feeding was more erratic, and changed more or less every hour, reaching its lowest between 1300-1500 hrs. at Point Calimere (See graph 1). When feeding on the shore or along the mud line, often picked up the prey by a series of rapid jabs—(' Stitching ' ?) (Burton 1971). Occasionally observed dashing after an insect (?) along the shore line. When feeding in water they were seen picking up from water probably some insects or larvae that were floating ; but were never seen probing (at that depth).

Very alert and active, often on the move, settling down *en masse* at a place, standing motionless for a second or two, and raising *en masse* all of a sudden, emitting soft—*tsch—tsch* or *chick—check* and circling for a minute or two before settling down again.

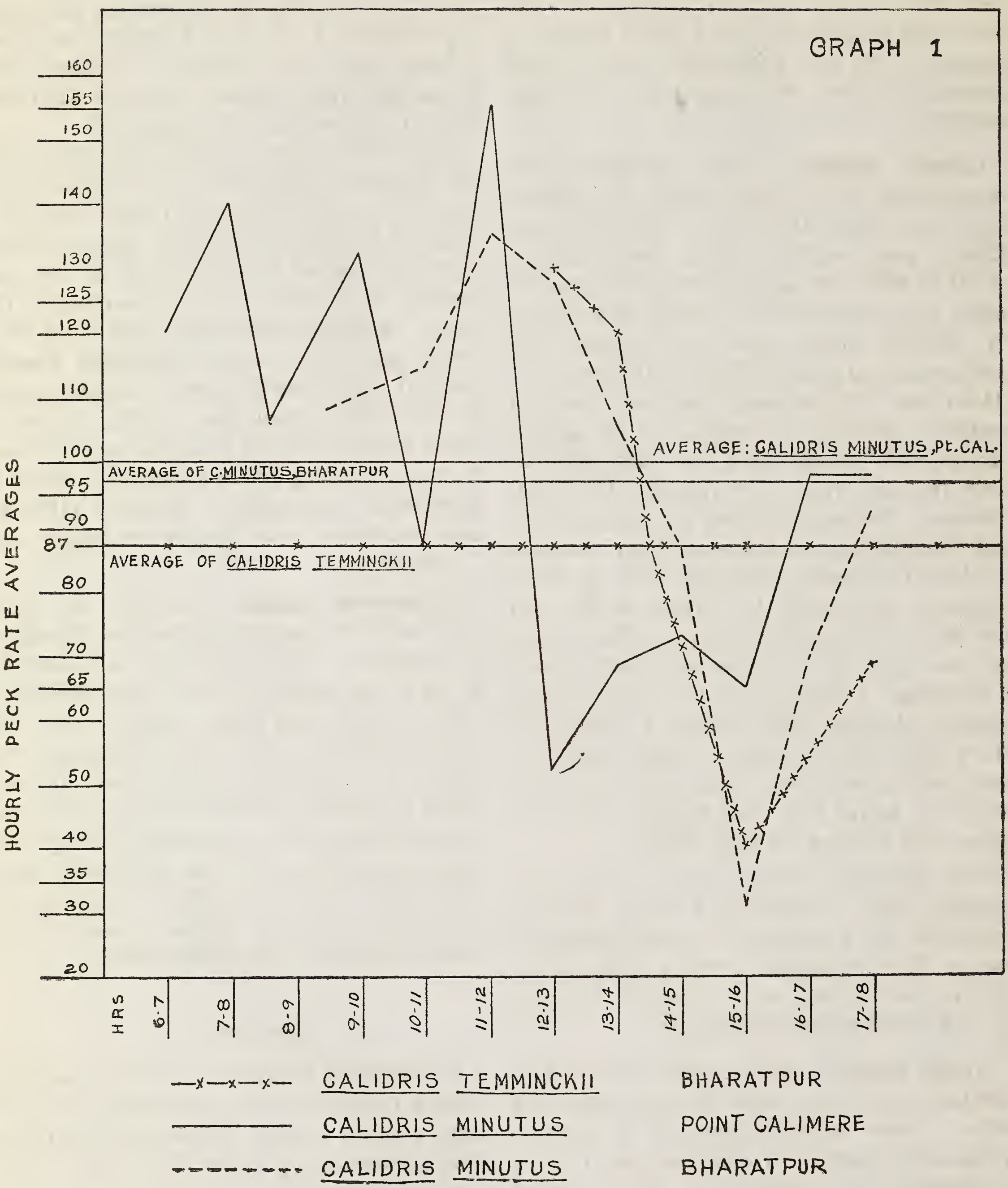
Tringa totanus: Seen singly only once at Bharatpur and four times in association with other waders (mixed flocks of *T. totanus, Philomachus pugnax, T. glareola and Calidris temminckii*) but observations were recorded on ten occasions at Calimere, mostly in ' knee ' deep water—(See horizontal distributional chart). From the peck rates it would appear that it feeds actively during morning and evening hours and a slow rate of feeding was noted between 0900 and 1200 hrs. A sudden drop in the peck rate was noted between 0800 and 0900 hrs. (See Table 2) (Graph 4).

Occasionally seen probing with head and bill completely submerged ; sometimes skimming the water surface with open bill, neck stretched in front and only the lower mandible immersed, (rather in the manner of the scissorsbill) as it moves forward, running in the water. A similar observation was made on a *Tringa nebularia*, probably collecting floating material. A *Tringa nebularia* was seen moving its bill quickly from side to side, keeping it partly open—while the bird was on the move. A similar feeding method was also noted in *Himantopus himantopus.* Witherby (1938-41) also mentions this feeding technique for *T. nebularia.*

Philomachus pugnax: Swarms of these birds were common during October-November at Bharatpur. The largest flock estimated to be of about 8,000, was seen near Bharatpur village on inundated fallow—but they were very restless settling *en masse* and rising again. Fed largely on vegetable matter—seeds (greyish brown in colour) of several varieties were noted from the stomachs, 10 stomachs averaged 304 seeds, highest being 410 and the smallest being 127. Sexes have obviously a tendency to flock or feed separately as was evident from the field observations and ringing catches.

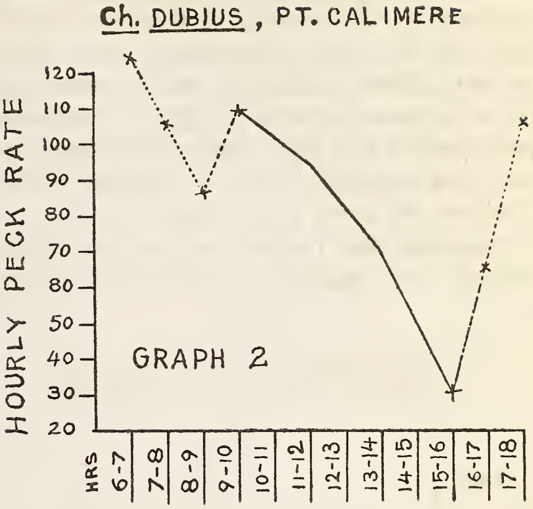
DISCUSSION

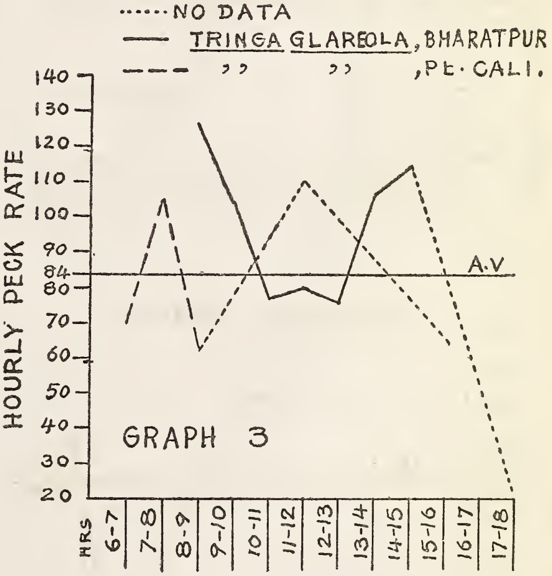
Non breeding individuals of several species of waders remain in India throughout the northern summer without migrating to their breeding grounds as is evident from the BNHS bird migration reports. Daniel & Somane (1975) have pointed out this and observed *Tringa totanus* at Visakhapatnam coastal swamp during


GRAPH 1
HOURLY PECK RATE AVERAGES
160
155
150
140
130
125
120
110
100
95
90
87
80
70
65
60
50
40
35
30
20
AVERAGE: CALIDRIS MINUTUS, Pt. CAL.
AVERAGE OF C. MINUTUS, BHARATPUR
AVERAGE OF CALIDRIS TEMMINCKII
HRS
6-7
7-8
8-9
9-10
10-11
11-12
12-13
13-14
14-15
15-16
16-17
17-18
—x—x—x— CALIDRIS TEMMINCKII BHARATPUR
———— CALIDRIS MINUTUS POINT CALIMERE
- - - - - - CALIDRIS MINUTUS BHARATPUR

June-August 1974, which evidently stay backs. The peak period at Point Calimere seems to be Nov.-Dec. as is evident from the catches at the ringing station. Usually the NE Monsoon showers occur at Calimere during October-Jan. The peak month of movement at Point Calimere on the outward migration is March as shown by the data collected in the field. ' Extensive flocking apparently occurs during March amongst *Calidris minutus* and *Calidris testaceus*; 1166 of the former were ringed in March as against 96 in February, the figures for *C. testaceus* being 1001 in March and 104 in February. ' (Daniel & Somane 1975.)

A comparison of the number of birds and the species ringed at both these study areas reveals the habitat preference of the species. However, methods of trapping were different in these two localities—but on the whole field observations and sight records show that the composition of the wader populations are definitely distinct in these two areas—as was reported already by Daniel & Somane (1975).





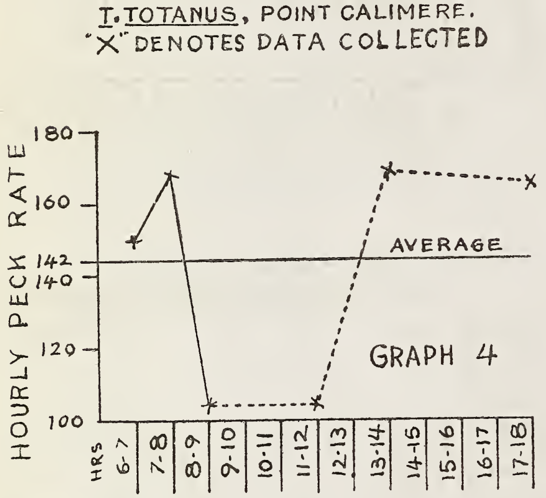
COMPARATIVE CATCHES OF CERTAIN WADERS

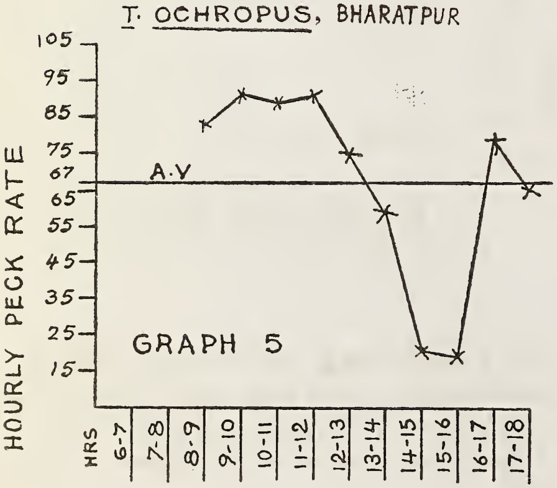
	Bharatpur	Point Calimere
Charadrius dubius ..	85	54
Tringa totanus ..	19	116
Tringa ochropus ..	52	—
Tringa glareola ..	1964	7
Calidris minutus ..	469	4715
Calidris temminckii ..	102	1

Peck rates: (See Table 2). The peck rates of different species differ considerably as is evident from the data collected, notwithstanding the fact that the data were independent of peck success. Among congeneric species, however, the difference appears to be minor between species of *Calidris*, but quite significant between species of *Tringa* where the larger *totanus* curiously appears to have a higher peck rate than the other two species studied. This high peck rate could be due to larger food requirements of the birds, or poor peck success, or abundance of food items.

In *Tringa glareola*, the peck rates were similar at Pt. Calimere and at Bharatpur despite the fact that the observations were made in two different ecological environments and in two different months (Graph 3). However, peck success and prey species taken have not yet been established, and we cannot further elucidate the point at this stage.

Regarding the feeding routine and hourly feeding rate changes a comparison of the tables yield some interesting information; In *Calidris minutus* at Point Calimere the feeding rate changed erratically, practically for every hour, the peak being between 1100-1200 hours. In Bharatpur the peak was between 1100-1200 hrs. However, the lowest rate of feeding was observed at Pt. Calimere between 1200-1300 hrs. whereas at Bharatpur it was between 1500-1600 hours, *i.e.* almost 3 hours later. The former is a sea coast area while the latter an inland freshwater jheel without any influence of the tidal rhythms characteristic of the former. By and large these observations, and fluctuating feeding rates suggest that there is a diurnal rhythm of activity upon which as Witherby suggested (1938-41) is super-imposed a tidal rhythm of lower intensity which is known to apply only in winter at coastal areas. Similar diurnal rhythms were observed in purple sandpipers *Calidris maritima* by Faere (1966). Behaviour of the prey items which might differ in these two localities and in different months, during different hours might also be possible for the peck rate fluctuations.



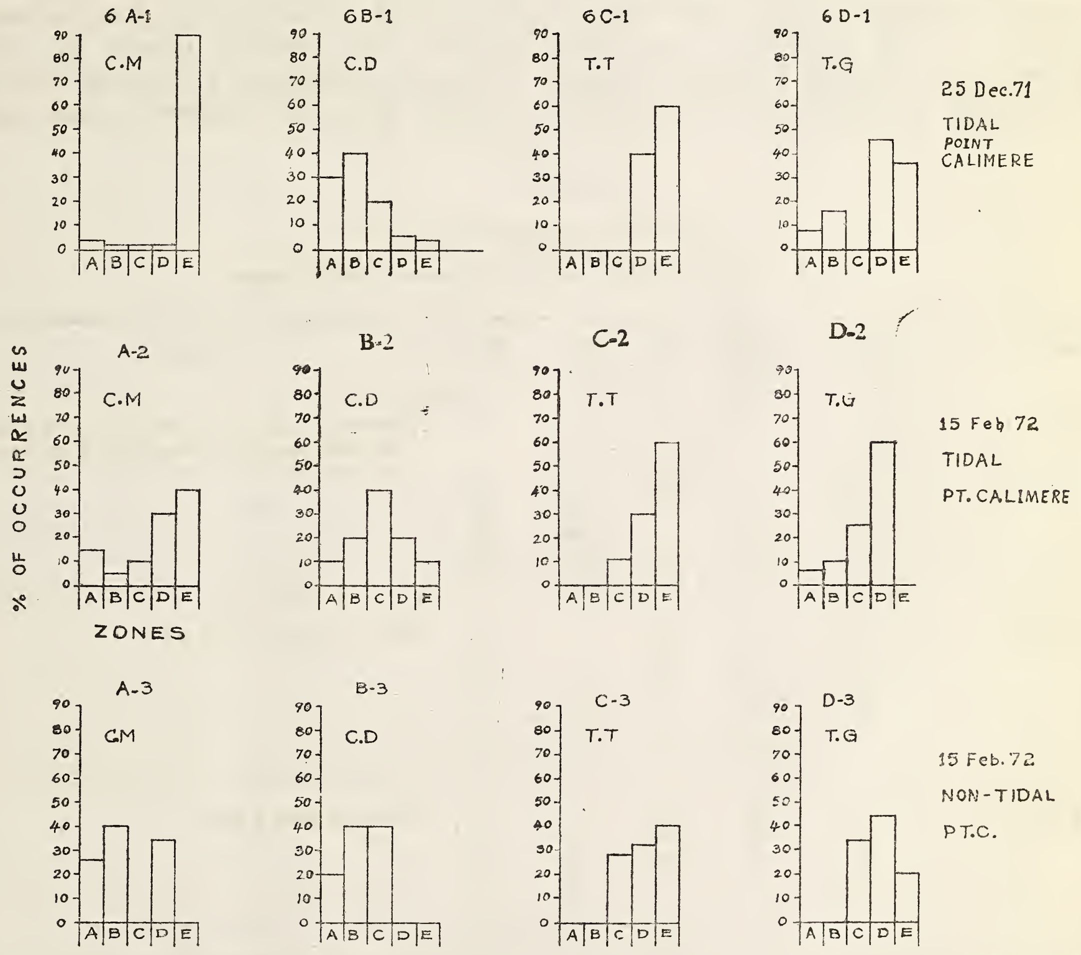


Tringa totanus fed at its lowest rate between 0900-1200 hrs. and highest rate between 1400-1800 hours. In *T. ochropus* the highest rate was noted between 1000-1200 hrs. which gradually decreased to the lowest between 1500-1600 hrs. and suddenly increased at 1700 hrs. (Graph 5). In *T. glareola* there seems to be much difference between the Bharatpur and Point Calimere feeding rates at a given hour—which again might be due to dietary differences or to the fact that the former observations were made more or less immediately after migration when the dietary needs were more while the Calimere birds were observed at a time when they had settled down in their winter quarters.

Another significant fact noted in all the species was that the feeding rates in February tended to be more than those in December and were more or less equal to those in October-November. This might perhaps support the general consideration that the dietary needs for fat accumulation to recoup the spent energy are more in months of October (immediately after arrival) and before return migration. This broadly supports the weight changes that correspond with the peck rates.

HORIZONTAL DISTRIBUTION OF BIRDS

C. minutus fed mostly in water (Zone E) during December. Only about 10% of them fed on the shore line or over a surface with thin film of water (See graph 6A). However, by



25 Dec.71
TIDAL
POINT
CALIMERE

15 Feb 72
TIDAL
PT. CALIMERE

15 Feb. 72
NON-TIDAL
P.T.C.

HORIZONTAL DISTRIBUTIONAL DATA

C.M = CALIDRIS MINUTUS
C.D = CHARADRIUS DUBIUS
T.T = TRINGA TOTANUS
T.G = TRINGA GLAREOLA

GRAPH.6

February only about 40% (See Table 3) of them were feeding exclusively in Zone E and remaining 60% were feeding in other zones including about 30% in shallow zones. On the same day, data were collected from a non-tidal area and none were seen in zone E, but about 65% of them were seen feeding in Zones A and B. In *Tringa totanus* the percentage of birds feeding in deep waters (Zone E) remained unchanged between December and February at Point Calimere in tidal areas. However, there appeared a significant change in percentage of birds feeding at the water's edge between tidal and non-tidal areas during February at Point Calimere. More birds were seen feeding at water's edge in non-tidal areas than in tidal areas. *Charadrius dubius* completely avoided deep waters in non-tidal areas though it was observed feeding in deep waters in tidal areas. In case of *Tringa glareola*, none of them were seen feeding at the water's edge in the tidal area in December but about 25% of them were seen at the edge by February. However, very negligible number of birds were seen in deep water in the tidal area in February, about 20% were seen in deep water

TABLE 3

HORIZONTAL DISTRIBUTIONAL DATA

% of occurrences in tidal and non-tidal areas at Point Calimere

Date	Zones	CM	CD	TT	TG	Remarks
25 Dec. 71 ..	A	4	30	—	7	Tidal area. Based on a minimum of 4 counts for each species in an area of 1 sq. km.
	B	2	40	—	15	
	C	2	20	—	—	
	D	2	6	40	45	
	E	90	4	60	33	
		100	100	100	100	
15 Feb. 72 ..	A	15	10	—	5	Tidal area. PTC 7.00 a.m.
	B	5	20	—	10	
	C	10	40	10	25	
	D	30	20	30	60	
	E	40	10	60	—	
		100	100	100	100	
15 Feb. 72 ..	A	25	20	—	—	Non-tidal area. 6 p.m.
	B	40	40	—	—	
	C	—	40	30	35	
	D	35	—	30	45	
	E	—	—	40	20	
		100	100	100	100	

Note.—Figures slightly rounded off.

CM = *Calidris minutus*
CD = *Charadrius dubius*
TT = *Tringa totanus*
TG = *Tringa glareola*

in non-tidal areas and practically none in the zones A and B. However, here again, in the absence of data on prey species and their availability, no conclusions are possible.

FLOCK COMPOSITION

See Table 1. The data reveals that all the species are more or less sociable, feeding in association with others among them. *Tringa glareola* was noted about 50% of the time singly and about 32% in association with others at Bharatpur and 60% and 20% respectively at Point Calimere. Flocks of 6-10 or more are common only in 3 species studied *C. dubius*, *Tringa glareola* and *C. minutus*.

ACKNOWLEDGEMENTS

I am indebted to Dr. Sálim Ali, D.Sc., F.N.A., and dedicate this paper to him on the eve of his 81st birthday. This work would not have materialised but for his encouragement and guidance. I thank Mr. J. C. Daniel, Curator of the BNHS for his suggestions and help while conducting this study. Thanks are also due to all my colleagues at the BNHS.

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BREEDING BIOLOGY OF BULBULS, *PYCNONOTUS CAFER* AND *PYCNONOTUS LUTEOLUS* (CLASS: AVES, FAMILY: PYCNONOTIDAE) WITH SPECIAL REFERENCE TO THEIR ECOLOGICAL ISOLATION

V. S. VIJAYAN[1]

(*With two plates and six text-figures*)

INTRODUCTION

According to Gause (1934) congeneric, sympatric species with identical ecological requirements cannot co-exist in the same area. This concept had been propounded by various other workers from Darwin (1859) to Elton (1927), though it is commonly referred to as 'Gause's Hypothesis' or 'Principle'. This hypothesis has been tested and found true for a variety of bird species in Europe, America and Australia (Lack 1971). In India no serious research on this aspect has so far been undertaken except on vultures in Gir forest (Grubh 1974). The present paper deals with various aspects of breeding biology of *P. cafer* and *P. luteolus* and tries to analyse the mode of ecological isolation between the two while breeding.

No systematic investigation of the breeding biology of these two species has been done before. Baker (1932) gives a general review of their breeding, and most of his conclusions are drawn from the scattered notes of others, based mainly on casual observations on one or more pairs. However, satisfactory but generalized details are available on the size, shape and colour of the eggs (Blanford and Oates 1863, Hume and Oates 1889, Whistler 1928, Baker 1932, Sálim Ali and Ripley 1971). The nature of the nest, nesting materials and other particulars of the breeding biology are not given in detail in any of these works. Scattered notes on some of the features of the breeding biology particularly of *P. cafer* are given by Barnes (1889), Betham (1897), Torth (1902), Matthews (1919), Sálim Ali (1930), McCann (1931), Dutt (1932) and Lamba (1968). Notes on the breeding of a pair of *P. cafer* in a building are recorded by Dixit (1963).

STUDY AREA (PLATES 1 & 2)

The study was undertaken at Point Calimere Wildlife Sanctuary, situated on a low promontory on the Coromandel coast (10°18′N, 70°51′E) in the Tirutturaipundi Taluk of Thanjavur District, Tamil Nadu, approximately midway between Madras and Cape Comorin. The elevation of the area is about 4 metres. For more details of the area see Daniel (1968) and Vijayan (1976). Intensive study was conducted around a place called Puthukulam. The area included two ridges or well forested strips with three open grassy areas; the outer two open areas separated the two ridges from the adjacent strips of forest and the middle one separated these two ridges.

Point Calimere experiences a prolonged dry season. It gets most of its rain from the north-east monsoon, which usually sets in

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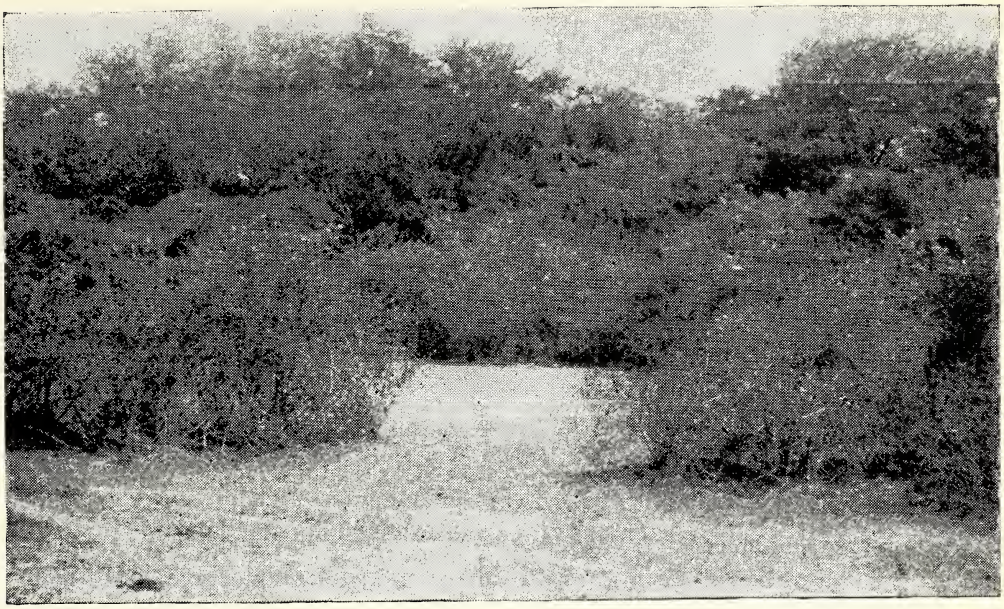
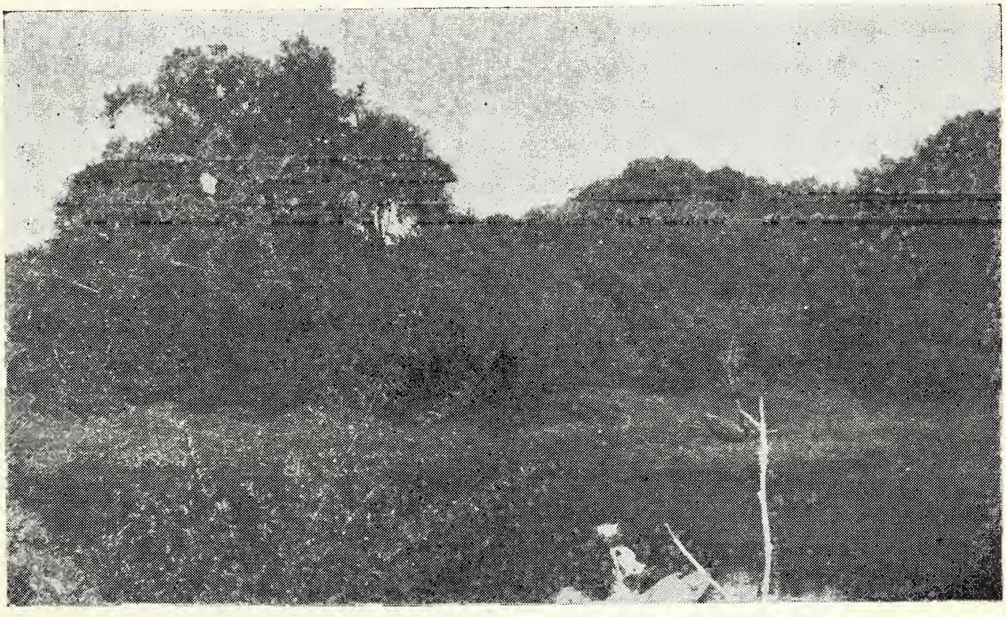
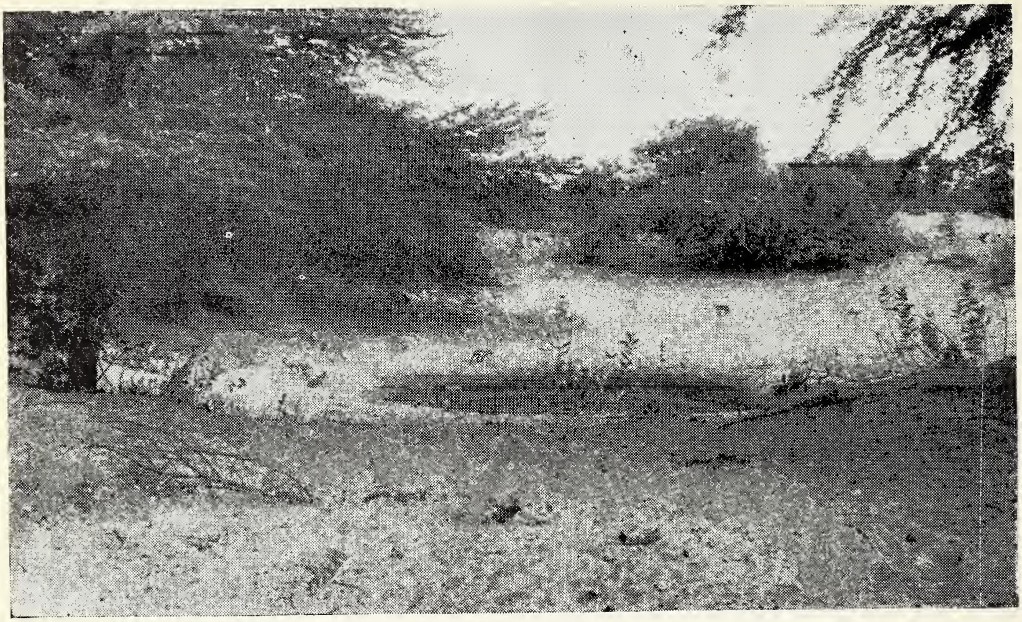
Vijayan : Bulbuls

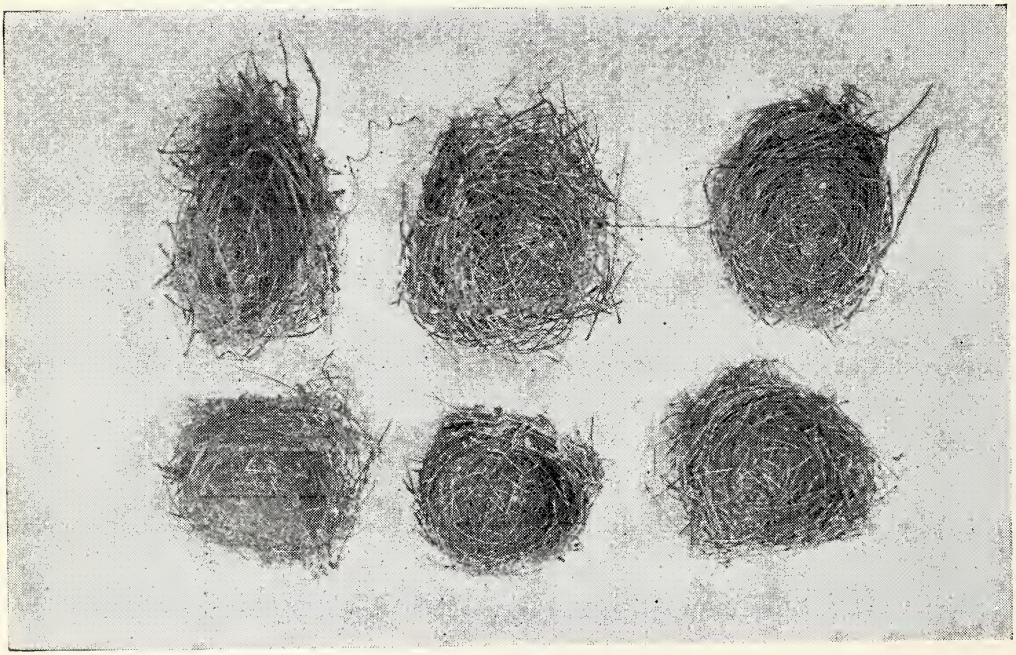




Above : The scrub jungle in Point Calimere with grassland.

Below : Intensive study area during monsoon ; open areas between the ridges are flooded.





Above : Puthukulam pond the only permanent water source inside the study area.

Below : Nests of *P. luteolus* (upper row) and *P. cafer* (lower row).

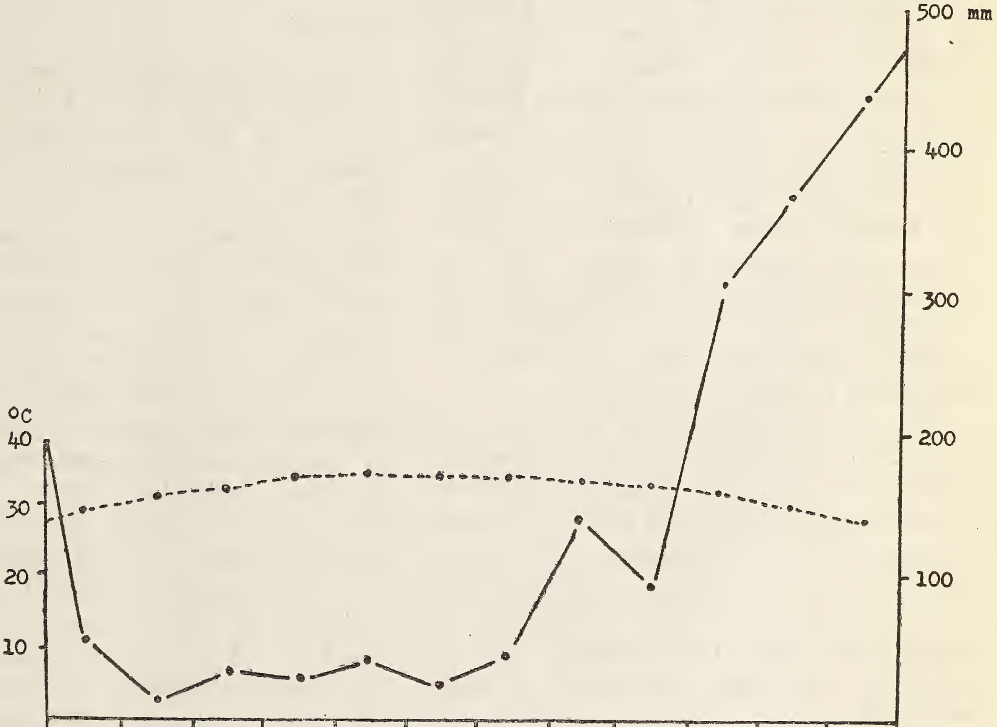
by the middle of August or the beginning of September and continues till December and at times till the middle of January. The rains are usually light during August-September. Heavy rain occurs during the end of the year. Average rainfall for 11 years in this region is 1580 mm. The hottest month of the year is May (Fig. 1).

Vegetation of Point Calimere is typical of the Tropical Dry Evergreen Forest (Champion 1936). As the best vegetative formation is stunted, the average height of the forest is 2 to 4 m. See also Blasco & Legris (1973) and Vijayan (1976). The forest in this area is discontinuous, being intersected by numerous open grasslands. Also, the presence of numerous tidal inlets and creeks of varying length and width cuts off the continuity of the forest. The whole area is flooded during rainy season.

Breeding season of *P. cafer* and *P. luteolus* at Point Calimere :

Method of Study :

Checking the area regularly for nests : An attempt was made to locate all the nests in the



	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall in mm	53.1	12.2	34.4	30.8	40.1	26.7	43.7	144.4	95.3	306.4	368.4	437.6
No.of rainy days	3.1	0.5	1.9	2.2	2.2	1.7	3.1	6.5	5.5	10.6	12.3	9.8
Max.temp. in °C	29.5	31.0	32.9	34.1	35.1	34.5	34.5	34.0	33.6	32.2	30.2	28.8

Rainfall : Average for 11 years, 1963-1973.
Maximum temperature : Average for 9 years, 1963-1971.

Fig. 1. Ombrothermic diagram of Vedaraniam.

study area. A similar method was adopted by Gaston (1973) for long-tailed tits. Ten to fifteen hours were spent every week searching for nests. Nests noted while observing other activities were also counted. A few nests were located while being built, by watching the birds carrying nesting material. A few were traced by following the birds carrying food. The study was conducted from October 1972 to February 1974.

RESULTS AND DISCUSSION

Breeding season:

During the period of 16 months, a total of 48 nests of *P. cafer* and 64 of *P. luteolus* were studied. From the distribution of the nests in different months it appears that the breeding season as well as the peak periods of breeding of *P. cafer* and *p. luteolus* at Point Calimere vary from year to year (Table 1). In general, the breeding season of both species extends roughly from August to March with two uncertain peaks, one in October and the other in February. Year to year variation in the breeding season and peak of breeding is reported in Chaffinch (Newton 1964).

There was a peak breeding period for both the species during October 1972 and February 1973. The next peak breeding period for *P. cafer* was September 1973 and for *P. luteolus* February 1974. In September there was not much breeding of *P. luteolus* and it was more or less the same for *P. cafer* in February. It suggests that these two congeners at times breed in the same season and at times separately.

There are cases where closely related congeneric species of apparently similar ecological requirements breed in the same area at different times (Thomson 1950). Lockie (1955) reports that even though several species of Corvidae live in the same area, their breeding seasons vary. In the present case of *P. cafer* and *P. luteolus*, two of the peak periods of breeding coincided, whereas one did not. Hence it is suggested here that their ecological requirements are dissimilar, but when these requirements occur in the same month the breeding season coincides and when they occur in different months the breeding season varies accordingly.

Factors determining the breeding seasons of *P. cafer* and *P. luteolus*

PHYSICAL FACTORS

Rainfall:

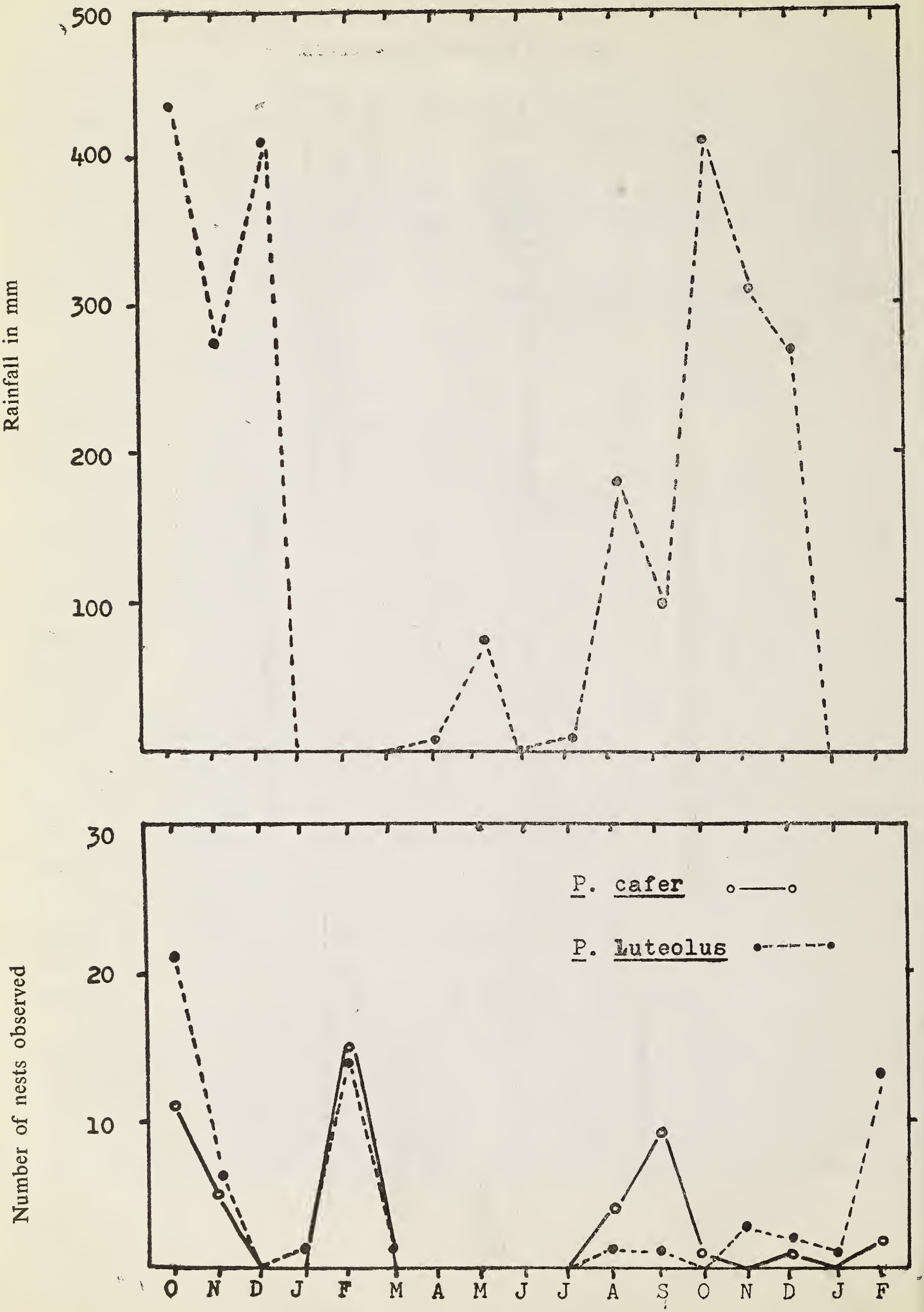
The onset of monsoon does not stimulate breeding activities in these bulbuls though it does in the Baya Weaver *Ploceus philippinus* (Sálim Ali and Ambedkar 1957; Ambedkar 1958) and *Turdus grayii* (Skutch 1950). In the Galapagos finches--*Geospizinae*—also rain is necessary to provide immediate stimulus (Lack 1950a). In the African *Pycnonotus capensis*, *P. tricolor* and *P. tricolor layardi* breeding is scheduled by the end of heavy rains (Vincent 1946-1949). In Indonesia breeding of birds generally starts by the close of rainy season and reaches the peak before the driest month (Voous 1950). In Usambara 5°S. most of the land birds avoid the long rains and begin to nest in anticipation of the short rains (Moreau 1950). In *P. cafer* and *P. luteolus* no such correlation is noted. They breed both in the months of heavy rain and in the months when there is absolutely no rain (Fig. 2). In 1972 and 1973, the rainfall was the highest in October, but only in the former year did they breed in October. In the latter year there was no breeding in October except by a single pair of *P. cafer*. This clearly indicates that breeding is not very much correlated with rainfall. (Coefficient of correlation is 0.073 in *P. cafer* and 0.0160 in *P. luteolus*).

TABLE 1

PERCENTAGE DISTRIBUTION OF NESTS OBSERVED IN EACH MONTH

	1972			1973												1974	
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
P. cafer	22.9	10.4	—	—	31.3	—	—	—	—	—	8.3	18.7	2.1	—	2.1	—	4.2
	(11)	(5)	—	—	(15)	—	—	—	—	—	(4)	(9)	(1)	—	(1)	—	(2)
P. luteolus	32.8	9.4	—	1.6	21.9	1.6	—	—	—	—	1.6	1.6	—	4.7	3.1	1.6	20.3
	(21)	(6)	—	(1)	(14)	(1)	—	—	—	—	(1)	(1)	—	(3)	(2)	(1)	(13)

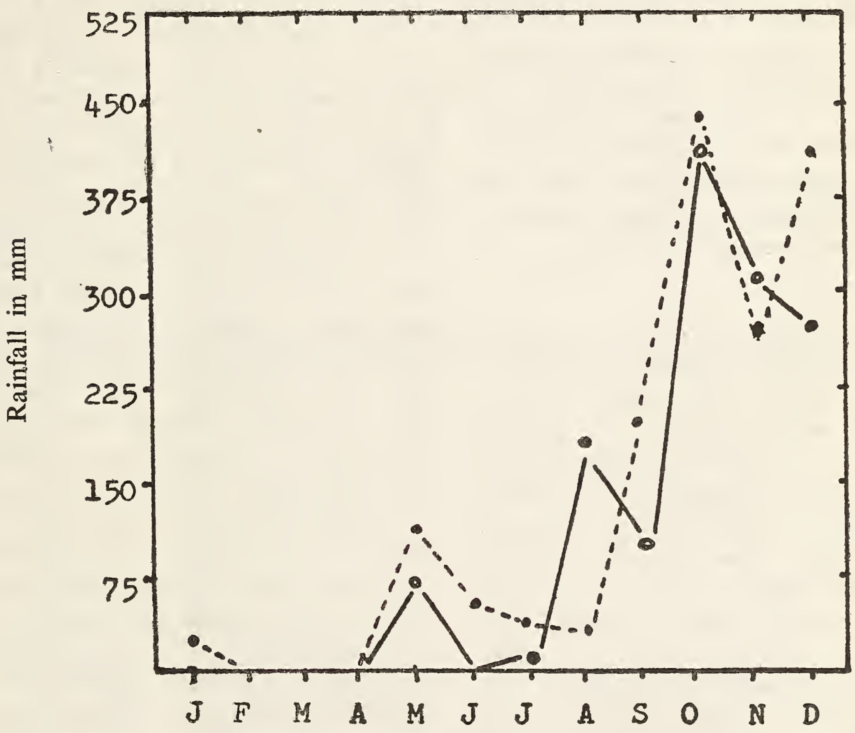
Figures in parenthesis are actual numbers.


500
400
300
200
100
Rainfall in mm
30
20
10
Number of nests observed
P. cafer
P. Luteolus
O
N
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F

However, the effect of distribution of rain through the year on the general biota may affect the breeding season. A rainfall of 200 mm in a day, and the same amount distributed over several days, makes a remarkable difference in the vegetation and thus on the general biota. During the first half of 1972 the rainfall was 197.6 mm, whereas it was only 78.7 mm in 1973 (Fig. 3). The poor fruiting of plants in October 1973, might be due to the poor rainfall in this period, and the same reason is attributed to the poor insect abundance during this period. The breeding of birds is naturally expected to be low when both insects and fruits are available in lesser quantitites. Hence the breeding is indirectly related to the distribution of rainfall at Point Calimere.

Humidity :

Both bulbuls avoid the months May, June and July when the relative humidity is comparatively very low (below 70%). Three out of the four peak periods of breeding occurred in the months when the relative humidity was between 77 to 79%.



Total rain up to June in 1972 : 197.6 mm
Total rain up to June in 1973 : 78.7 mm
Total rain in 1972 : 1600 mm
Total rain in 1973 : 1358 mm

Fig. 3. Distribution of rain during 1972-1973.

Temperature :

Temperature variation is not very pronounced in Point Calimere (Fig. 1), the maximum being 35.1°C in May and minimum 28.8°C in December. However, the bulbuls avoid the hottest months May, June and July and prefer the cooler months for breeding.

Day length :

Day length which apparently has an indubitable effect on the breeding of birds in temperate regions (Lack 1950 b) is ineffective in tropical regions in general (Skutch 1950, Moreau 1950) and this seemed to be very much so in the bulbuls at Point Calimere. It is doubtful whether the difference in day length of less than an hour, is sufficient to cause any change in the retino—hypothalamo—hypophyseal system of bulbuls. The fact that they breed in February, a month with the shortest days in the year, and in October when the days are comparatively longer, provides negative, evidence for such assumption.

Biotic factors

Nest site & material : Nest sites are available for both species throughout the year, and so are the nesting materials in general. However, one of the most important material for *P. luteolus*, the dry hanging roots of *Tinospora cordifolia* is available more in February than in October. These roots are several metres long, and green in October when the bird naturally finds it difficult to collect them, while in the dry season the collection is rather easy since they become dry and brittle. The nesting of *P. cafer* in October starts before the area is flooded due to heavy rain. This helps them to collect more *Desmodium triflorum*, a trailing climber that forms the outer covering of the nest.

Availability of food : The sexual cycle of a bird is generally regulated by various external factors which ensure that breeding takes place at a time when there is sufficient food for the young. Two of the peak breeding periods of each species, October 1972 and February 1973 were correlated with the general increase in the insect population as well as the abundance of fruit. But one peak of each species did not show such correlation (Fig. 4). (In October the actual insect abundance was much higher than that is shown in Figures 4 and 5. During this month only one method was used to estimate the insect abundance, whereas in the subsequent months 3 more methods were used.) In September 1973, though the general insect population was much less than in October, a peak period of breeding was observed for *P. cafer*, and in February 1974, though the insect as well as fruit abundance was much higher there was not much breeding activity in the species. This suggests that the high breeding activities are not necessarily correlated with the general abundance of fruits and insects, and in turn suggests that there must be some essential factors which stimulate the breeding of *P. cafer*, and that these factors were present during all the peak periods of breeding in this species—October 1972, February and September 1973. However, in a place like Point Calimere where the general ecosystem is so complex and intricate due to the unpredictable succession of rain and drought, the appearance and disappearance of large number of migratory birds, the presence of a very large number of plant and insect species, and above all due to the continued anthropogenic activities in the forest, it is very difficult to single out a particular factor which determines the breeding of a bird. Nevertheless, an attempt is made.

It was found that the appearance and abundance of caterpillars was one of the factors which determined the breeding time of *P. cafer*. All the peak periods of breeding were correlated with a high occurrence of

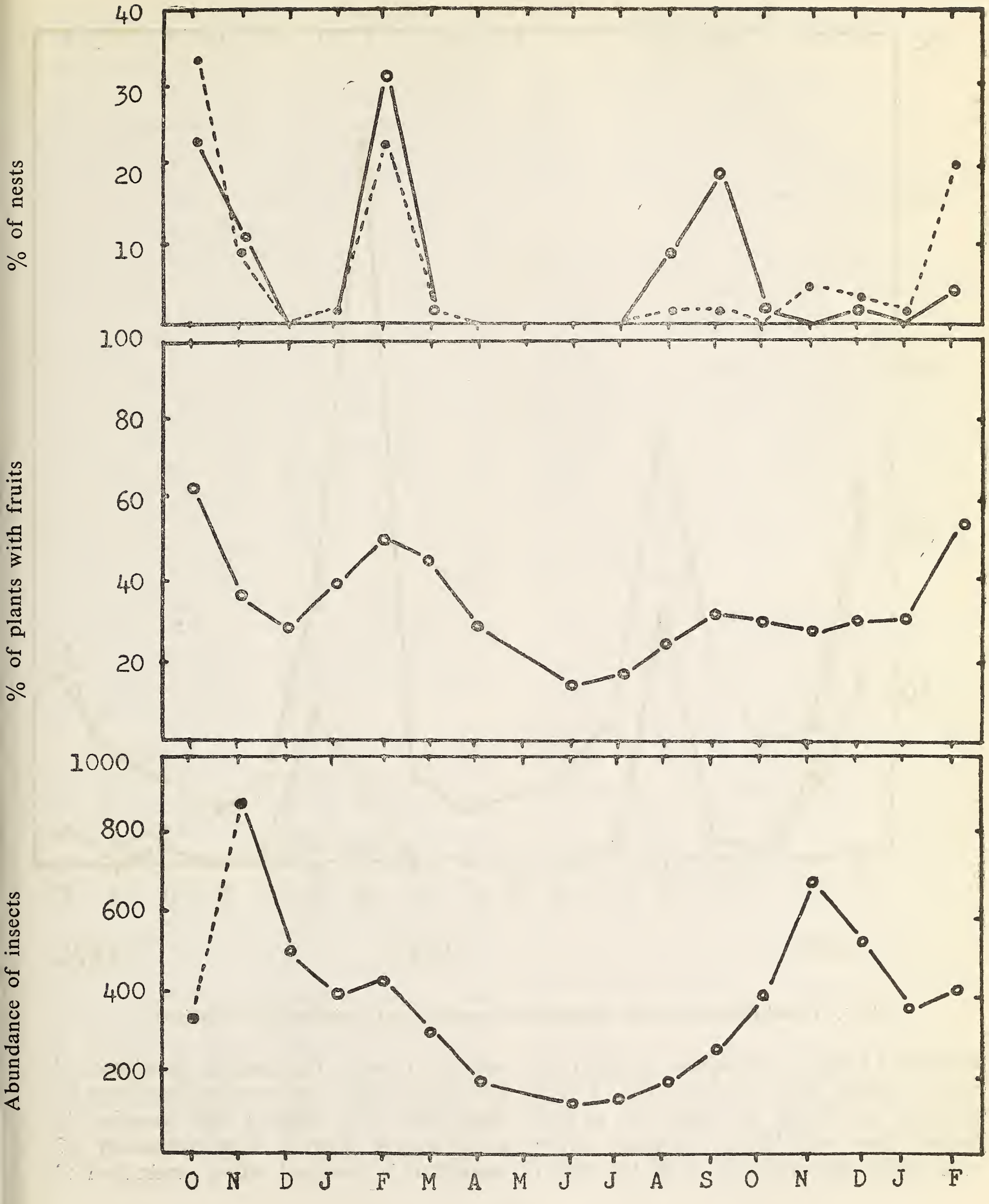


Fig. 4. Correlation between the nesting activities of bulbuls and the general abundance of fruits and insects. (During October 1972 only one method was used to estimate insects abundance).

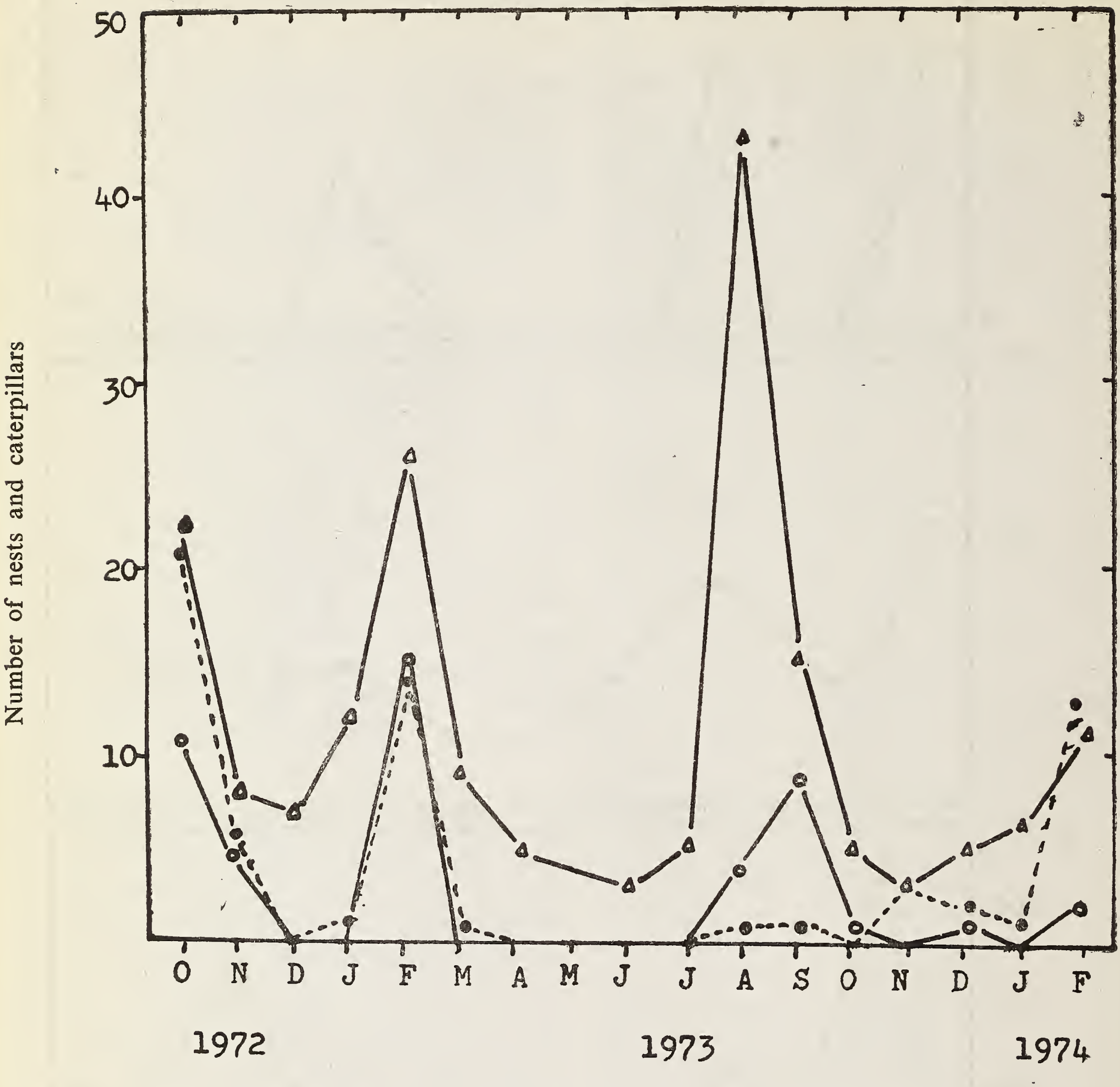


Fig. 5. Correlation between the abundance of caterpillar and nesting activities of bulbuls.

caterpillars (Fig. 5). Though in August there was a sudden spurt of caterpillars, a high breeding activity was not noted, but in September there was intense breeding activity even though the caterpillar level had fallen almost to half. The general abundance of insects and fruits was comparatively more in September. This suggests that breeding is possible only when a high availability of caterpillars is correlated with a certain level of insect and fruit abundance. In February 1974, all the major insects as well as fruits were plentiful but the caterpillars were very few, and so was the breeding of *P. cafer* (Figs. 4 and 5). The appearance of caterpillars as a factor for laying has been reported in many cases, as in Robin (Lack, D. and Silva, E. 1949) and in Great and Blue Titmice (Gibb, J. 1950). A close correlation between a single factor and breeding is reported by Lockie (1955) in the appearance of earthworms and the commencement of the breeding season of blackbirds and thrushes. In the case of *P. cafer*, the caterpillars are important not only as food for the young, but also for the incubating bird. Incubating birds were observed several times visiting swarms of caterpillars and devouring them. The distance between the nest and the caterpillar swarm was noted to be below 6 m. So it is suggested here that the presence of caterpillars is one of the factors influencing the female to lay, as it is a major food for herself as well as the young. Lack's hypothesis (Lack 1968) that breeding time has evolved in relation to the needs of the laying female as well as those of the young is supported by this study.

The breeding time of *P. luteolus* is correlated with the fruiting of plants, since they feed their young more on fruits than on insects. In all the months when they bred intensively in the study area the fruit availability was high, as in October 1972, February 1973 and 1974, and there was no breeding when the fruit production was poor as in October 1973 (Fig. 4). The following statistical analysis lends support to the above conclusions. The correlation of four major factors—number of caterpillars, insect population, fruit abundance and rainfall—with breeding is tested. Linear mathematical models were assumed.

$$Y - \beta0+\beta1x1+\beta2x2+\beta3x3+\beta4x4$$

where

Y — number of nests of the species concerned
X1 — number of caterpillar
X2 — Insect population
X3 — Fruit abundance and
X4 — Intensity of rainfall (total rainfall in a month/number of rainy days in that month)

(The constants $\beta0$, $\beta1$, $\beta2$, $\beta3$, and $\beta4$, were estimated by the method of least squares from the data collected).

Stepwise linear regression analysis was done. The coefficients of correlation matrix showed that the breeding of *P. cafer* has got a maximum correlation with the number of caterpillars (0.6000) and then with the abundance of fruit (0.5974). In the case of *P. luteolus* maximum correlation is with the abundance of fruit (0.7962) and then with the number of caterpillars (0.3751) (Table 2).

In the case of *P. cafer*, 36% of the variation in breeding is explained by the number of caterpillars (See R^2 values Table 3). 58.42% is explained when both the number of caterpillars and fruit abundance were considered together in the model. Addition of insect population in the model contributes only 0.08% variation, *i.e.*, when three variables are put together—caterpillar, fruit abundance and insect population 58.50% of the variation is explained. The introduction of the additional variable *viz.*, intensity of rainfall did not increase the percentage of variation in the dependent variable. A substantial amount of variation 41.5% remains to be explained.

Similarly in the case of *P. luteolus* 63.35% of variation is due to the abundance of fruit; number of caterpillar contribute only an addition of 3.95% of variation. The introduction of the other two variables—insect

TABLE 2

MATRIX OF SIMPLE CORRELATION COEFFICIENT

	X_1	X_2	X_3	X_4	BL_1	BL_2
	1.0000	—0.2465	0.2273	—0.0279	0.6000	0.3751
		1.0000	0.3601	0.4066	0.0785	0.1694
			1.0000	0.1418	0.5974	0.7962
				1.0000	0.0730	0.0160
Mean values	11.5625	388.3750	537.8750	14.2750	3.0000	4.0000
Standard deviations	10.6706	201.3815	218.9197	14.7659	4.5607	6.3456

X_1 — Caterpillar.
X_2 — Insect population (excluding caterpillar).
X_3 — Fruit abundance.
X_4 — Intensity of rainfall (Total rainfall/number of rainy days).
BL_1 — *P. cafer.*
BL_2 — *P. luteolus.*

population and intensity of rainfall—does not contribute much to the variability. Thus 67.33% of variation is explained while 32.67% of variation remains unexplained.

General breeding biology of *P. cafer*, and *P. luteolus*.

Nesting site :

P. cafer as well as *P. luteolus* preferred small bushes either on the sides of open areas or at the centre of the ridges for nesting. A few nests of *P. cafer* were observed alongside the railway lines, but rarely of *P. luteolus*. The surroundings of Puthukulam on the eastern ridge is a favourite nesting area for both species. There is a tendency to select the same site for nesting in successive seasons; this habit is more common in *P. cafer*.

Inter- and intra-specific proximity of the nests : Based on the nesting dispersion the family Pycnonotidae has been characterised as ' solitary nesters ' (Lack 1968). The present investigation revealed that this term is not strictly applicable for describing the nesting disposition of *P. cafer* and *P. luteolus* since 2 or more nests of both species are often very close to each other. The shortest distance between two nests of *P. luteolus* was about 3 metres, and between those of *P. cafer* about 2.5 m. During the peak period of breeding 3 nests of *P. cafer* were observed within a radius of 5 metres, 3 nests of *P. luteolus* were found in a line, separated from each other by 3 and 4 metres only. 2 to 3

TABLE 3

SUMMARY TABLE FOR THE STEPWISE REGRESSION MODEL

Dependent Variable	*P. cafer*				*P. luteolus*			
Number of the step ..	1	2	3	4	1	2	3	4
Variable entered ..	X_1	X_3	X_2	X_4	X_3	X_1	X_4	X_2
Cumulative sum of squares reduced upto this step. ..	112.32495	182.25727	182.49646	182.51501	382.85271	406.86945	411.29573	411.71324
Sum of squares of the dependent variable	312.0000				604.0000			
F-ratio for sum of squares due to regression	7.87554*	9.13093+	5.63680*	3.87625*	24.23696+	13.41574+	8.53735+	5.88814+
Multiple correlation coefficient(R) ..	0.60001	0.76430	0.76480	0.76484	0.79615	0.82072	0.82520	0.82562
R^2 ..	0.36001	0.58415	0.58492	0.58498	0.63385	0.67363	0.68096	0.68165
Intercept constant ..	0.03480	—4.86680	—5.04473	—5.04896	—8.41271	—9.09516	—8.73686	—8.52816
Independent Variables in the regression equation. ..	X_1	X_1 X_3	X_1 X_3 X_2	X_1 X_3 X_2 X_4	X_3	X_3 X_1	X_3 X_1 X_4	X_3 X_1 X_4 X_2
Partial regression coefficients corresponding to the independent variables in the regression equation. ..	0.25645	0.20923 0.01013	0.21394 0.00934 0.00072	0.21361 0.00984 0.00064 0.00262	0.02308	0.02173 0.12177	0.02212 0.11850 —0.03724	0.02249 0.11217 —0.03240 —0.00103
Standard errors of the partial regression coefficients corresponding to the Independent variables in the regression equation. ..	0.09138	0.07850 0.00383	0.08754 0.00443 0.00484	0.09180 0.00463 0.00549 0.06593	0.00469	0.00472 0.09676	0.00491 0.09977 0.07093	0.00565 0.11186 0.08034 0.00669
Computed T values corresponding to the Independent variables in the regression equation. ..	2.80634*	2.66546* 2.64709*	2.44379* 2.21915 0.14888	2.32704* 2.12487 0.11583 0.03970	4.92310+	4.60723+ 1.25850	4.50479+ 1.18782 —0.52501	3.98331+ 1.00274 —0.40328 —0.15455

* Significant at 95% level.
+ Significant at 99% level.
not significant at 95% level.

and at times 4 nests of both species were often seen within a radius of 5 to 8 metres in the Puthukulam area, more often nests of *P. cafer*. A more or less similar situation has been observed in the Long-tailed Silky Flycatcher and described as 'loose colonies' (Skutch 1965) even though the distance between the nests in that case was several times more than in these bulbuls. The shortest distance Skutch observed between two nests was about 25 m, and he also included a nest situated about 200 m from the others in his 'loose colony'. Hence it would be more correct to say that at Point Calimere *P. cafer* and *P. luteolus* nest in 'loose colonies', especially in the peak periods of breeding. Solitary pairs were, however, seen breeding outside the main breeding area.

The usual distance separating the nests of the two species during the peak breeding period varies from 3 to 6 metres, and at times more. The shortest distance observed was one metre. However, it was noted that every nest of one species is not invariably accompanied by a nest of the other species. The significance of this interspecific clustering of nests is apparently that it offers protection from predators. One species warns the other of the approach of enemies which in turn attacks and chases the predator. The former is invariably *P. luteolus*, whereas the latter is *P. cafer*. Smaller predators like *Dendrocitta vagabunda* and *Centropus sinensis* were often mobbed by a pair or more of *P. cafer*. Not a single instance was observed of *P. luteolus* chasing the predator. Congeneric species nesting in such close proximity has been reported earlier by Skutch (1951).

No deliberate association of the nesting of these two bulbuls with any other species of birds was observed at Point Calimere. However, Betham (1897) has recorded a nest of *P. cafer* along with the nests of *Terpsiphone paradisi*, *Oriolus oriolus* and *Rhipidura aureola* on a Babul tree in Baroda. Matthews (1919) has noted *P. cafer* nesting in company of *Acridotheres tristis*, *Artamus fuscus*, *Lonchura malabarica* and *Copsychus saularis* on a palm tree. Hutson (1947) recorded four cases of *P. cafer* nesting with *Dicrurus adsimilis* around Delhi. In two of these cases the nests of *Terpsiphone paradisi* were also noted. He pointed out that nesting had started synchronously in three cases where the nesting was successful.

Choice of nesting plant :

Both species of bulbul prefer thorny plants for nesting ; this is more evident in *P. luteolus* than in *P. cafer* (Table 4). The reason for the preference for thorny plants can be attributed to the higher nesting success so achieved. This assumption is discussed below :

Xeromphis spinosa, a small deciduous thorny tree less than 3 m in height is the most favoured plant for nesting by both species of bulbul. The second in the order of preference is *Dichrostachys cinerea* for *P. cafer* and *Gymnosporia emarginata* for *P. luteolus* (Table 5). In all, 27 species of plants were found to be used by both species of bulbul. 41% of these were shared by both, whereas 33% were used by *P. cafer* only and 26% by *P. luteolus* only. However, those plant species which were used more than 5% is the same in both the bulbuls. This shows that there is not much difference in their selection of plant species for nesting.

Vertical distribution of nests :

The height of location of nests varies from 0.5 to 3 m in *P. cafer*, and from a little under 0.5 to a little under 3 in *P. luteolus* (Table 6). The most favoured height of *P. cafer* is between 1.5 - 2 m, whereas this is 0.5 to 1.5 m for *P. luteolus*. As the height increases there is a marked decrease in the preference by *P. luteolus*,

TABLE 4

FREQUENCY OF NESTS ON THORNY AND THORNLESS PLANTS

	P. cafer	*P. luteolus*
Percentage of nests on thorny plants	55 (40)	72 (58)
Percentage of nests on thornless plants	45 (33)	28 (23)

Figures in parenthesis are actual numbers.

TABLE 5

FREQUENCY (IN PERCENTAGE) OF NESTS OBSERVED IN VARIOUS PLANTS

	P. cafer	*P. luteolus*
Thorny plants		
Xeromphis spinosa	17.8	23.5
Dichrostachys cinerea	15.1	12.4
Gymnosporia emarginata	6.8	14.8
Fluggea leucopyrus	1.4	4.9
Toddalia asiatica	2.7	4.9
Zizyphus oenoplia	1.4	2.5
Phoenix pusilla	1.4	1.2
Capparis zeylanica	2.7	—
Pithecellobium dulce	1.4	—
Plectronia parviflorum	1.4	—
Acacia planifrons	1.4	—
Atalantia monophylla	1.4	—
Randia malabarica	—	3.7
Gmelina asiatica	—	1.2
Carissa spinarum	—	1.2
Azima tetracantha	—	1.2
Thornless plants		
Cassia fistula	13.7	6.2
Clerodendron inerme	10.9	11.3
Manilkara hexandra	9.6	4.9
Memecylon edule	2.7	2.5
Cassia auriculata	2.7	—
Dodonaea viscosa	2.7	—
Syzygium cumini	1.4	—
Ehretia ovalifolia	1.4	—
Hugonia mystax	—	1.2
Azadirachta indica	—	1.2
Grewia rhamnifolia	—	1.2

Note.—Total number of nests observed in *P. cafer* is 73 and in *P. luteolus* 81. Percentage is calculated from this.

TABLE 6

VERTICAL DISTRIBUTION OF NESTS

	Height in metre						
	0.5	0.5-1	1-1.5	1.5-2	2-2.5	2.5-3	3
P. cafer ..	—	11	19	28	5	7	3
P. luteolus ..	1	31	27	12	6	4	—

whereas there is an increase in the preference by *P. cafer* upto 2 metres. The difference in the average nesting heights of *P. cafer* and *P. luteolus* is significant. The chi-square value was found to be 20.32 ($p<0.01$ df$=4$).

Both species of bulbul show a tendency to build the nest comparatively high up when on a thornless plant. Lack and Lack (1958) reported a similar phenomenon in the longtailed tit, where the difference in height was more obvious.

Position of nest in the canopy :

There is an apparent segregation in the location in the canopy where the nest is built. *P. luteolus* invariably chooses the periphery of the bushes, whereas *P. cafer* places the nest more towards the centre. This behaviour superficially seems to be quite contradictory to the usual habits of both, where *P. luteolus* tends to confine itself to the interior of the bushes, whereas *P. cafer* keeps to the periphery. The possible reasons for *P. luteolus* nesting at the periphery are :

(1) Since *P. lutelous* is a more ' nervous ' and ' shy ' species, a nest at the periphery of a bush would be of advantage in the early detection of an approaching predator.

(2) A nest located at the periphery of a bush is less accessible to a predator than a nest in the centre (this point is discussed under Predation).

(3) This behaviour is perhaps an outcome of the interrelationship between the two species. It is always *P. luteolus* which warns of the approach of an enemy and *P. cafer* chases it away.

The possible adaptive significance of *P. cafer* nesting in the centre are :

(1) Since the clutch size is three, stronger support is necessary for the nest (in *P. luteolus* the clutch is of two eggs).

(2) Since three chicks have to be fed, the visits of the parents are naturally more than where the brood is of only two, and a nest in the centre of a bush is more suitable for avoiding detection by the predator.

(3) The fact that the birds prefer the periphery and tops of the bushes for foraging and other activities, suggests that normally they are less concerned about predators. This is more obvious when they are incubating. During rain, the incubating bird spreads its wings in such a way as to form an effective ' umbrella ' over the nest and its head is then tucked under the wing. In this position the bird would be more vulnerable if nesting at the periphery. Though incubating *P. luteolus* also spreads its wings over the nest during rain, it readily detects the approach of an intruder, whereas *P. cafer* can often be caught in this position.

Thus a nest at the centre of a bush is safer for *P. cafer*.

Method of Placing the nest :

P. cafer prefers to rest the nest at the junction of a bifurcated branch or on some similar substrate so as to get a firm support at the bottom. Also, at times it is placed at the junction where four or five branches meet and cross. *P. luteolus* invariably hangs the nest on thin branches. It seldom requires a support at the bottom. In many cases two sides of the rim of the nest are attached to adjoining branches, and the nest is hung between them like a hammock. In some cases one side of the body of the nest is attached to a thin live twig of the plant by a climber stem which forms the major body of the nest. Though the nests of *P. cafer* appear safer, predation is comparatively less on the nests of *P. luteolus*.

The nests :

The nests of *P. cafer* and *P. luteolus* are easily distinguished, the former having a definite cup-shape, and the latter lacking such a definite shape (Plate II). They are built of entirely different nesting materials. At times the nest of *P. luteolus* looks like an oval or a flattened cup.

The nest of *P. cafer* is hemispherical having a diameter of 62 mm (average of 10 nests) and a depth of 40 mm. The outer wall of the nest is formed mainly of the dry petioles of *Cassia auriculata* (70%) and the rest of the material is generally the stems and branches of the herbs *Aerva lanata*, *Oldenlandia herbacea*, *Borreria hispida*, *Borreria articularis* and *Cleome aspera*. The branches of *Aerva lanata* with flowers are often used. The outer lining of this thick wall is made up of a small trailing, much branched perennial herb, *Desmodium triflorum*. The inner lining of the cup is invariably done with a small, slender, loosely tufted grass *Eragrostis tenella*, the entire grass especially with its glumes is used. A few other grass shoots were also recorded but could not be identified, as they were dry without glumes. The rim and sides of the nests are attached to the adjacent branches with spider webs.

The nest of *P. luteolus* is never a cup or hemispherical, but a slight and at times very shallow oval. The average diameter of 10 nests is 55 mm and depth 25 mm. The outer wall of the nest is formed generally by the dry stems of climbers like *Mucuna prurita*, *Melothria maderaspatana* and *Asparagus racemosus*. Sometimes the stems of *Clitoria ternatea* were also used. The petioles of *Cassia auriculata* are used at times. Dry inflorescence of *Pithecellobium dulce* is used in February. The long hanging roots of *Tinospora cordifolia*, at times more than three metres long, form the major part of the inner lining. Usually no grass is found in the nest. The preference of climber stems to grass is an indication of the bird's averseness to descend to the ground.

The eggs :

Size and shape : The eggs of *P. luteolus* are slightly larger than those of *P. cafer* (Table 7). Both are oval in shape but the former is more elongate.

Colour : In general the colour of *P. luteolus* egg is lighter than that of *P. cafer*. The ground colour is pinkish in *P. cafer*, whereas it is reddish white in *P. luteolus*, white is invariably more in *P. luteolus*. The markings vary in the eggs of both species. As Hume and Oates (1889) noted, in *P. cafer* ' it takes every conceivable form, defined and un-defined-specks, spots, blotches, streaks, smudges and clouds ; their combinations are as varied as their colours which embrace every shade of red, brownish and purplish red '. In *P. luteolus* the markings are more profuse at the broader end of the egg ; the speckles are usually red, brown and lilac. The narrower end of the egg is very much lighter in colour being less speckled. A distinct ring around the broader end is a definite character of the egg of *P. luteolus*; this ring is present in *P. cafer* also but less distinct and some times totally absent. It is formed by more profuse speckles and blotches.

Clutch size :

The upper limit of the clutch size is three in *P. cafer* and two in *P. luteolus.* This is the normal clutch of both species. A clutch size of two and one also occurs at times in *P. cafer* and *P. luteolus* respectively (Table 8). A clutch size of more than two never occurs in *P. luteolus* (Ali and Ripley 1971) nor has a clutch size of more than three in *P. cafer* been recorded in the literature. However, Jerdon (1863) has once recorded four eggs in a nest of *P. luteolus* in Vellore. This can be an exceptional case. Torth (1902) has reported Pied Crested Cuckoo's eggs in the *P. cafer* nest.

Clutch size variation :

The clutches of the two peak breeding periods of the two species were compared. A variation in the clutches of the wet season and the dry season was observed in both. In *P. cafer* the largest clutch is laid in the wet season, *i.e.*, October-November, whereas in *P. luteolus* it is so in the dry season, February (Tables 9 & 10). This variation is more clear from the Table 11 & 12, where the percentage of different clutches are given. In the case of *P. cafer* the percentage of the

TABLE 7

EGG SIZE OF *P. cafer* AND *P. luteolus*

Species	Samples	Length		Diameter	
		Mean	Standard Deviation	Mean	Standard Deviation
P. luteolus ..	44 (60)	23.7 (22.9)	0.6946 —	16.4 (15.8)	0.6707 —
P. cafer ..	31 (100)	22.0 (21.1)	1.2992 —	17.0 (15.5)	0.5228 —

Figures in parenthesis, Baker (1932).

TABLE 8

CLUTCH SIZE OF *P. cafer* AND *P. luteolus*

Clutch (No. of eggs)	Frequency	
	P. cafer	*P. luteolus*
3	75(36)	—
2	25(12)	78(50)
1	—	22(14)

Actual number in parenthesis.

TABLE 9

CLUTCH SIZE VARIATION IN *P. cafer*

Clutch size	October	November	February
3	10	4	13
2	1	1	2
Average :	2.9	2.8	2.7

Note.—In February the unhatched eggs are 5 ; this makes the average clutch size of that month to 2.5

TABLE 10

CLUTCH SIZE VARIATION IN *P. luteolus*

Clutch size	October	November	February
2	13	3	11
1	8	3	3
Average :	1.6	1.5	1.8

TABLE 11

PERCENTAGE OF DIFFERENT CLUTCHES IN EACH MONTH IN *P. cafer*

Clutch size	October	November	February
3	90	80	87
2	10	20	13

Note.—In February 5 eggs are unhatched where the clutches were 3. Hence the actual clutch size in these cases are 2. So the percentage of clutch 3 is 50 ; whereas clutch 2 is 47.

TABLE 12

PERCENTAGE OF DIFFERENT CLUTCHES IN EACH MONTH IN *P. luteolus*

Clutch size	October	November	February
2	62	50	79
1	38	50	21

largest clutches is high in October, whereas in *P. luteolus* this is so in February.

The variation of the clutch size is correlated with the availability of food, the larger clutch is laid when the food for the young is most abundant (Lack 1954). This hypothesis holds true for both these species of bulbul. The food, especially caterpillars and insects, was more in October than in February. The difference between the insect population during the month of October and February was so high (Fig. 4) that even though the migratory birds were present during the former month, the actual number of insects available to the local birds might be higher during this period. Also, it was found (Vijayan, in preparation) that *P. cafer* feeds its chicks more with animal food than vegetable, hence the higher clutch size of *P. cafer* in October is correlated with the abundance of food available for the young. In the case of *P. luteolus* the average clutch size is comparatively higher in February than in October. From the food of the nestlings it was found that they were fed more with fruits than insects (Vijayan, in preparation). In February the ripe *Salvadora persica* fruits were the most abundant, and an analysis of the dried fruits of *Salvadora* (Fry *et al.* 1970) has shown that they are very rich in readily assimilable fructose and sucrose (82.5%). Also during February, though the actual fruiting is less than that in October, the fruit available to the local birds might be many times more because of the general decrease in the bird population due to the exodus of many of the migratory species. The difference between the abundance of fruit during the month of October and February was not very high (Fig. 4) so the presence of migratory birds during October would certainly affect the quantity of fruits available to the local birds.

Significance of the clutch size :

Clutch size is characteristic of each species and in nidicolous birds it has been evolved through natural selection to correspond with the largest number of young for which the parent can, on the average, provide enough food (Lack 1954, 1966, 1968 and also 1947 and 1948). Earlier Moreau (1944) had suggested with reference to African birds that 'availability of food for the chicks is almost irrelevant ; at most it would fix an upper limit to the brood that could be reared and conceivably, by adaptation, an upper limit to the size of the clutch'. Skutch (1949) contends that tropical birds do not raise as many young as they can. According to him there is an innate rhythm in food-bringing in the parents, and the rate of food-bringing is increased when they find the chicks are more hungry due to a large interval or when an additional chick is placed in the nest. Ricklefs (1970) suggests that clutch-size is an outcome of opposing predator and prey adaptations.

While accepting Lack's hypothesis (Lack 1954) that the clutch size is a heriditary characteristic of each species and has evolved through natural selection to correspond with the largest number of young for which the parent can, on the average, provide enough food, the following points are noted as important, at least for the cup-shaped nesters in the tropics where predation is extremely high.

Clutch size has evolved through natural selection to correspond with the largest number of chicks the nest can support.

Explanation :

As described above, the nest of *P. luteolus* is very shallow when compared to *P. cafer's* and is constructed and suspended in such a way that it cannot support the weight of more than two chicks. The instances where chicks fell from the nests as they grew older support this assumption. On two occasions the chicks fell down thus, when they were more than 7 days old.

In *P. cafer* three grown chicks completely fill the nest and there is no room for another ; the nestlings are rather uncomfortable inside the nest even when there are only three.

The question why these two species of bulbul cannot make bigger nests and lay larger clutches does not arise. The two species have the habit (described above) of covering the nest with the wings during rain. This is possible only if the diameter of the nest is shorter than the wing span. These facts suggest that the nest size is correlated with the size of the bird (applicable perhaps only to the cup-shaped nesters).

Clutch size has evolved through natural selection to correspond with the largest number of chicks the parent can effectively feed, minimizing the chances of betraying the nest to a predator.

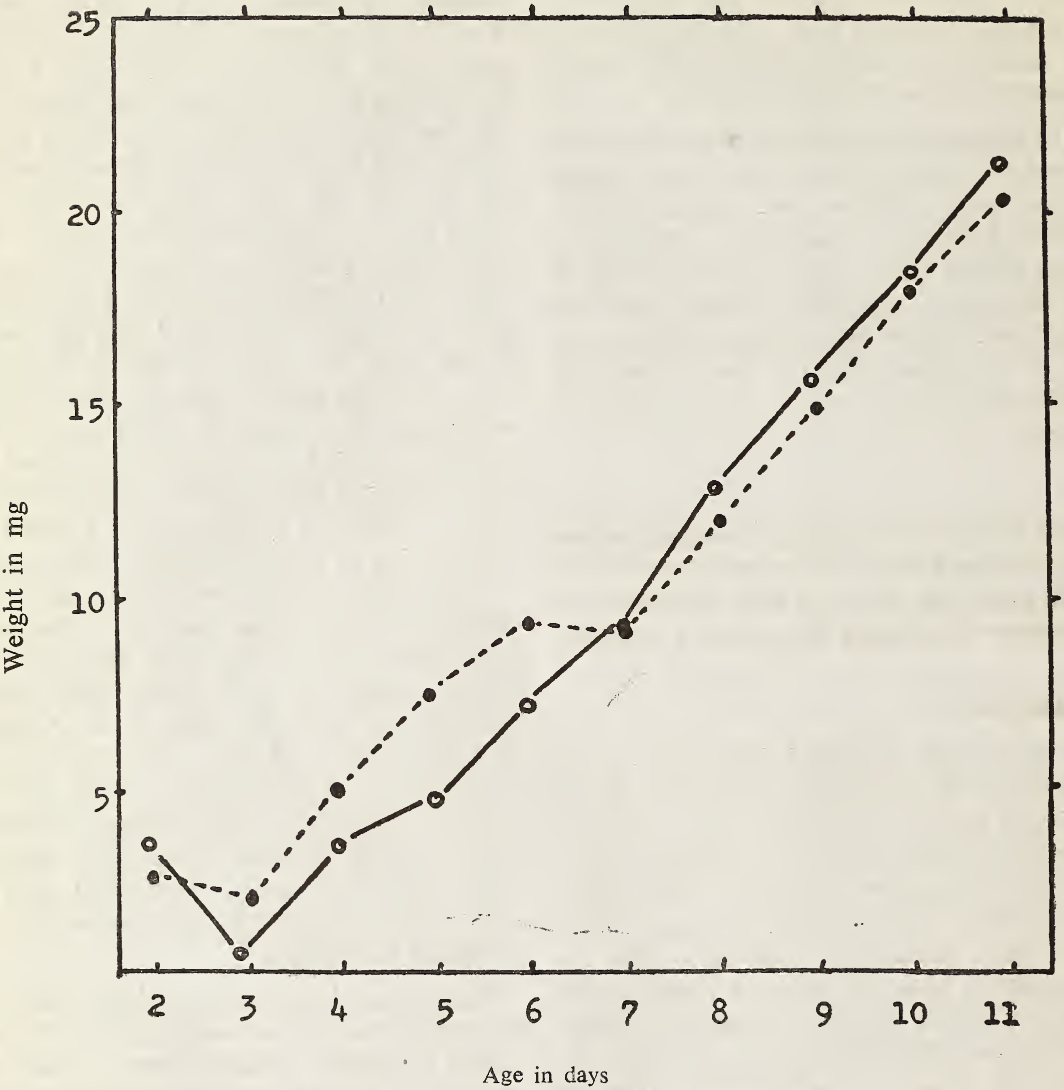
Explanation :

It is strongly suggested here that in the evolution of the clutch size in these two bulbuls, predation has had a paramount role. Natural selection prevents laying larger number of eggs, as it involves greater activities of the parents around the nest when there are more chicks and thus attracting predators. This is especially so when the nests are placed at the periphery of the bushes. The nesting success of these two bulbuls shows that the smaller the clutch the lesser the danger from predators and thus the greater the nesting success. Skutch had earlier (1949) maintained this view for the evolution of smaller clutch size in tropical birds compared to temperate birds.

Incubation and nestling period :

Much data on these aspects could not be collected because of the severe predation on eggs and chicks in the Point Calimere area. However, the following features are recorded : In *P. cafer* regular incubation commences usually after the laying of the second egg. The first egg is left unattended, but the parents visit the nest occasionally and at night roost on the same bush but they never incubate the first egg on the first night. Usually the female does the actual incubation, while all the other duties are attended to by both the parents. Dixit (1963) in Baroda noted that both parents incubate the egg. However, during the course of this study no male with incubation patch was noted in the netted population, and a colour marked pair also substantiated this observation. Incubation period is considered, as defined by Nice (1954) and Skutch (1945), to be the period from the laying of the last egg of a clutch to the hatching of the last nestling. This period in both *P. cafer* and *P. luteolus* is 11 days (only one case in each species observed). Marchant (1963) has recorded the same period for *P. leucotis.* Sálim Ali and Ripley (1971) have recorded the incubation period for *P. cafer* as approximately 14 days. The hatching is asynchronous in both species. The nestling period is 12 days in *P. cafer* (one case). Average nestling period of three broods of *P. luteolus* was 10 days (9-11 days). Unhatched eggs in both species remained in the nest even after the chicks had fledged.

There is an interesting correlation between the growth rate of the nestling of *P. cafer* and that of *P. luteolus.* Though there are only two chicks in *P. luteolus*, the increase in the average weight of the chicks per day during the first 6 days is more or less the same as in *P. cafer* where there are 3 chicks. However, the pattern of growth changes after the 6th day as the nestling *P. luteolus* grows faster than *P. cafer* (Fig. 6). Ricklefs (1968) has postulated that in tropical land birds slow growing species have two eggs in a clutch, whereas more rapidly growing species have 3 to 5 eggs. However, this is not borne out by the present limited data.



Note : In *P. luteolus* the weight is average of 2 chicks.
In *P. cafer* the weight is average of 3 chicks.

Fig. 6. Growth rate of nestling of *P. cafer* and *P. luteolus*. (Chicks hatched within a difference of one day; both nests from the same place.)

Breeding success :

The breeding success of *P. cafer* and *P. luteolus* at Point Calimere appeared to be exceptionally low. For a period of 16 months, out of the 134 eggs laid by *P. cafer* only 11 (8.3%), and out of 114 eggs laid by *P. luteolus* only 15 (13.2%) nestlings fledged (Table 13). Few studies have been done in India on the nesting success of passerine open nesters ; therefore a comparison with other areas is difficult. Sálim Ali (1930) notes that out of 6 nests of *P. cafer* under his observation none produced a fledgling that

TABLE 13

BREEDING SUCCESS OF *P. cafer* AND *P. luteolus* FROM OCTOBER, 1972 TO FEBRUARY 1974

	Total egg laid	Egg hatched	% egg hatched from laid	Fledged	% fledged from hatched	% fledged from total eggs laid
P. cafer ..	134	48	36.4	11	23	8.3
P. luteolus ..	114	34	29.8	15	44	13.2

flew. Skutch (1966) reports that in the tropical Central American lowlands the nesting success is 23.5% in the nests found in the forest and 37% in the clearings and secondary growth.

A correlation between the nesting success and the denseness of the vegetation cover was recorded. According to season the thickness of the vegetation can be divided into three categories. August to September : after the summer heat the vegetation becomes green, most of the deciduous plants sprouting new leaves ; so the vegetative cover during this period is neither dense nor open. October to December, dense cover ; January to March, the actual breeding period is February, when most of the deciduous plants have shed their leaves and the vegetation looks very dry ; the cover then is sparse. The nesting success was the highest in both species when the cover was densest (Tables 14 & 15). Between January and March the nesting success in *P. cafer* was nil and in *P. luteolus* it was negligibly small, viz. 3.8%. In August/September a total of 4 eggs of *P. luteolus* was under observation of which none hatched, whereas from 34 eggs of *P. cafer* 3 hatched and fledged.

Hatching success :

Hatching success depends mainly on two factors ; hatching failure and egg loss. The former might be due to infertility of eggs or the death of the embryo—very rare in both species of bulbul. However, *P. cafer* suffered a comparatively high percentage of hatching failure, which occurred mainly during the dry season when the cover was less dense and the food—especially insects—comparatively scarce. The high percentage of hatching failure may be due to inefficient incubation during this period, caused by the parent having to spend much time in search of food. Murton (1966) relates the low hatching success in wood pigeon to the same reason. Egg loss was higher in *P. luteolus* than in *P. cafer*, and was extremely heavy in the dry season when the cover was less dense (Tables 16 & 17). Most of the egg loss in both species was due to predation. The high predation on the eggs of *P. luteolus* during February is attributed to the cover factor. Since cover was very sparse, the nests were more vulnerable to predators, and more so when situated at the periphery of the bushes. The egg loss in *P. cafer* was the same both during the period when the cover was dense and when it was less dense.

Fledging success :

The fledging success was higher in *P. luteolus* than in *P. cafer* (Tables 18 & 19). In both the species there is a striking difference in the nesting success between the wet and dry season. This difference is significant statistically too as calculated students' value of $t = 3.723$ with 32 degrees of freedom in the case of *P. luteolus* and as calculated students' value of $t = 2.489$ with 43 degrees of freedom in the case of *P. cafer*. Both the values are statistically significant. The success of fledging depends on nestling

TABLE 14

NESTING SUCCESS OF *P. luteolus*

	Total egg laid	Hatched	Fledged	% fledged from total eggs laid
Aug.-Sept. ..	4	0	0	0
Oct.-Dec. ..	53	24	13	24.5
Jan.-Mar. ..	57	10	2	3.8

TABLE 15

NESTING SUCCESS OF *P. cafer*

	Total egg laid	Hatched	Fledged	% fledged from total eggs laid
Aug.-Sept. ..	34	3	3	8.8
Oct.-Dec. ..	50	26	8	16.0
Jan.-Mar. ..	48	19	0	0

TABLE 16

HATCHING SUCCESS OF *P. luteolus*

Months	Clutches	Total eggs	Hatched	% hatched	% of hatching failure	% of egg loss
Oct.-Dec. (wet season)	32	53	24	45.3	—	54.7
Jan.-Mar. (dry season)	30	57	10	17.5	3.5	79

TABLE 17

HATCHING SUCCESS OF *P. cafer*

Months	Clutches	Total eggs	Hatched	% hatched	% of hatching failure	% of egg loss
Oct.-Dec. (wet season)	18	50	24	48	2	50
Jan.-March (dry season)	17	48	19	39.6	10.4	50

TABLE 18

NESTLING SUCCESS IN *P. luteolus*

Months	Clutches	Total eggs	Hatches	Fledged	% fledged from hatched
Oct.-Dec. (wet season)	32	53	24	13	54.2
Jan.-Mar. (dry season) .. ∴	30	57	10	2	20

TABLE 19

NESTLING SUCCESS IN *P. cafer*

Months	Clutches	Total eggs	Hatched	Fledged	% fledged from hatched
Oct.-Dec. (wet season)	18	50	26	8	30.7
Jan.-Mar. (dry season)	17	48	19	—	—

deaths and predation. The former was very rare in both species (Table 20). The nestling death observed in *P. luteolus* is attributed to the flimsy construction of the nest and its mode of suspension. The nestling when 7 days old fell down during heavy rain and gale, the attachment of the nest on the twig being feeble. Of the two nestling deaths observed in *P. cafer* one is presumed to be due to starvation. In this case two out of the three nestlings were missing, and had most probably flown and one was found dead in the nest. The dead one was the youngest among the chicks due to asynchronous hatching and it is presumed here, that it received less food while competing with the elder ones. It was only 17.5 gms in weight while the other two were 23 gms on the last observation, two days earlier. In nestling swifts starvation has been noted to be the major cause of death (Lack, D. and Lack, E. 1951). High starvation deaths are reported in S. W. Ecuadorian birds (Marchant 1960). In the second case of nestling death it is not certain whether it was due to predation on the parent bird or starvation. Of the three eggs, two hatched and one of the nestlings, 7 days old, was found dead on the ground below the nest ; the second chick and unhatched egg were missing.

However, predation is the major cause of nestling loss in *P. cafer* as well as *P. luteolus* (Table 20). Predation on nestlings is higher during the dry season than in the wet. Here again vegetation cover is the most important factor. The high predation on the chicks of chaffinch is attributed to the thinness of cover (Newton 1964) and it is found to be so in the case of greenfinch (Monk 1954). The frequent visits of the parents to the nest for feeding is another major factor which can cause heavy predation ; and this is more so in *P. cafer* which has three chicks to feed than in *P. luteolus*, which has two. Young (1963) attributed the frequent visits of parent birds to nest, as one of

TABLE 20

MODE OF NESTLING LOSS

	P. cafer	*P. luteolus*
Oct.-Dec. (wet season)		
Total nestling loss ..	18	11
Percentage preyed upon ..	89	82
Percentage lost by death and other reasons ..	11	18
Jan.-Mar. (dry season)		
Total nestling loss ..	19	8
Percentage preyed upon ..	100	100

the major factors which caused the high nestling loss he found in Redwinged Blackbirds. Skutch (1949) opines that tropical passerines have smaller clutches as an adaptation to reduce the increased activity of the parents during the nestling period.

The major predators at Point Calimere :

It is difficult to see the actual predation of eggs and chicks and most of the conclusions in this respect in the present study as in published literature (Lack 1954, Skutch 1966) are inferential, based on circumstantial evidence. However, in the present study, a few instances of predation were directly witnessed. The mongoose (*Herpestes edwardsi*) seemed to be the greatest single cause of nestling loss in the study area. Snakes though seen were rare, but they undoubtedly purloined a good number of eggs. One was seen emptying a nest, while another was noticed climbing up on a nesting plant, but it was unsuccessful as a crow-pheasant *Centropus sinensis*, filched the eggs before the snake could reach the nest. The important bird predators were *Centropus sinensis* and *Dendrocitta vagabunda.* The former was seen eating the chicks. There is no direct evidence against *Dendrocitta vagabunda*, but it was noticed several times being chased away from the nesting area by *P. cafer.* *Spilornis cheela* was once observed eating the chicks of *Aegithina tiphia. Eudynamys scolopacea* though common during October/November was not seen robbing the nests ; but Sálim Ali (1930 and pers. commu.) has observed them swallowing bulbul's eggs. *Calotes* lizards were neither seen stealing the eggs, nor was there any reason to suspect so, since the incubating bird was never provoked by the appearance of a *Calotes* near the nest. However, Sálim Ali (1930) reports that one of the clutches of *P. cafer* in Kihim appeared to have been preyed on by *Calotes.* Pereira (1961) reports *Calotes* attempting to take entangled *Erithacus svecicus* and *Ploceus philippinus* from mist nets. Some cases of predation are difficult to explain. For instance, in a clutch of three eggs of *P. cafer* the eggs hatched asynchronously. The first chick disappeared soon after hatching, leaving the other two eggs in the nest ; the second disappeared as it hatched leaving the third egg in the nest. This egg disappeared after two days. In another instance, in the nest of a *P. luteolus*, the egg shells were found intact in the nest, having a very small hole on one side ; the predator must have sucked the contents. A similar case is reported by Murton (1958) in wood pigeon and he mentions that Corvids are notorious for sucking the eggs of many birds in this way.

Adaptation of *P. cafer* and *P. luteolus* against predators :

Nesting at the periphery by *P. luteolus* is an adaptation to reduce predation although the loss of eggs was greater in this species. It would be expected that these species which nest at the centre of bushes have a better nesting success, but it was found not to be so in this study. Closer observation showed that mongoose, the principal predator in this area, found it hard to reach nests on the periphery of bushes. Also the bird predators like *Centropus sinensis* and *Dendrocitta vagabunda* often preferred to have a steady perch for feeding. In the case of *P. luteolus* nests, these birds would have to hover over the nest to get at the contents, and such an action was not seen.

Passage to and from the nest: If one side of the nesting bush is open and the other covered, the parent bird enters the nest through covered area. This is invariably so with *P. luteolus* while incubating. But they leave the nest from the open side. This behaviour reduces the chances of the predator in detecting the nest by following the parent bird.

Smaller clutch size is considered to be an adaptation for reducing the chances of predation.

Broken-wing tactics : Often when the nest of *P. cafer* was approached both parents raised a hue and cry and one of them practically fell to the ground, scrambling forward with apparent difficulty, beating wings and giving distress calls. If the purpose of this behaviour is to distract the attention from the chicks, the ruse was successful in one case where the chicks flew away while the observer was watching this behaviour. This behaviour has been reported in *P. leucogenys leucotis* by Cumming (1903) and in *P. jocosus* by Aitken (1903). The latter reports that the bird employed this tactic even when crows approached the nest.

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BREEDING SEASON IN A TROPICAL POPULATION OF THE HOUSE SPARROW[1]

R. M. NAIK[2] AND LALIT MISTRY[3]

(*With ten text-figures*)

INTRODUCTION

The House Sparrow *Passer domesticus* (Linnaeus) is of near cosmopolitan distribution. It is found throughout Europe, North Africa, Egypt, Sudan, Arabia, Iran, Central Asia, Northern Manchuria, Northern Mongolia, Pakistan, India, Sri Lanka and Burma. It is introduced in North America, Australia, New Zealand, South Africa, Chile and elsewhere. Summers-Smith (1967) has given an interesting account of the dispersal of the genus *Passer*. *Passer* for its dispersal seems to have followed the trail of man, so that, like man, it occupies a wide variety of habitats at present.

Several scientific reports on biology of the house sparrow and the other species of *Passer* have appeared from Europe and North America. After the initiation of world-wide studies of granivorous birds in 1965 under the auspices of the PT (Productivity Terrestrial) section of the International Biological Programme, the research out-put on *Passer*, particularly *P. domesticus* and *P. montanus* has increased. A news-letter on 'International Studies on Sparrows' published from the Polish Academy of Sciences since 1967, provides useful information on the research activities of numerous workers actively engaged in researches on the granivorous birds, and has published a comprehensive bibliography on *Passer*. Recent researches on the House Sparrow in North America are summarized in a series of papers organized in a monograph published recently (Kendeigh 1973). Some results of the studies on several granivorous bird populations in different parts of the world, made during the tenure of PT section of the International Biological Programme, have been published in a volume on the productivity, population dynamics and systematics of granivorous birds (Kendeigh and Pinowski 1972). While several populations of the House Sparrow in the temperate regions have been well studied, the tropical populations of this species have been barely touched. Our knowledge of the populations in the Oriental region is scanty ; some information on general biology and habits of the species collected by naturalists is summarized in several bird books, some of them covering the avifauna of certain specific regions of India (Ali 1945, 1953 and 1972 ; Whistler and Kinnear 1949).

Our studies formed a part of the International Biological Programme (PT section). The ultimate objective of the studies is to estimate the seasonal and annual changes in the reproductive rate of our sparrows. A preliminary report of the studies has been published earlier (Naik and Mistry 1972). A part of the studies has been reviewed briefly by Naik (1974). This paper on the breeding season of the house sparrow, is a part of the detailed report of our five-year studies; the other parts will be published elsewhere.

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Reproduction in birds is a continuous chain of events from the nest-building, copulation, ovulation and oviposition to the fledging of the young. This chain of events, once started, occurs at the species specific speed and can neither be staggered nor speeded up, but it must at the same time ensure a high survival rate for the brood (Immelmann 1971). The timing of the start of this chain of events is, therefore, most crucial for a bird population and is controlled by a most intricate mechanism. The oviposition of the first egg in a clutch, that is the starting of a clutch, is the earliest event of avian reproduction that can be conveniently recorded with a great degree of precision. In the ornithological literature, the starting of a fresh clutch of eggs is referred to as breeding and the period during which the fresh clutches are usually started in a population, is referred to as breeding season.

The population of house sparrow whose breeding season is described here, belongs to the subspecies *indicus*. This subspecies has the most extensive range among the three subspecies of *Passer domesticus* in India (Ali and Ripley 1974). Our population of the House Sparrow is strictly sedentary and breeds in loose colonies located in buildings. The sparrows visit their breeding colonies throughout the year—at all times of the day when they are nesting and only in the morning when they are not nesting. Within the colony, a nesting pair of sparrows often defends more than one nesting site, even though it breeds at one site at a time.

MATERIALS AND METHODS

One hundred nest-boxes were made available to the sparrows for breeding. The boxes were numbered and nailed to the wall, about 3 metres off the floor, in the verandahs or lobbies of the first and second floors of several buildings mainly in the university campus. The contents of the boxes were checked every fifth day during 1969 and 1973, and every day during 1970 to 1972. During every checking visit to a box, contents were recorded and the eggs were marked with Indian ink.

Precise and approximate dates of nesting events:

During 1970 to 1972, the nests were checked every morning so that timings of breeding in each nest-box were known precisely. In 1969 and 1973, the boxes were checked every fifth day. During these years, the dates of breeding in a nest-box could be approximated, when required, as follows. The sparrows usually lay 3 to 4 eggs in a clutch and the interval between the laying of successive eggs is about 24 hours. When the fresh eggs are found in a box on a day of nest-checking, the number of fresh eggs gives a clue as to how many days before checking the clutch might have been started.

Complete and incomplete clutches:

Occasionally a sparrow lays a clutch of one egg. Such a clutch may be an 'incomplete' clutch, but, it may be incubated by the parent and it may even produce a fledgling. For this reason, we have considered all clutches alike and have made no distinction between small and big clutches.

'Early' and 'late' broods:

In a multi-brooded species, such as the house sparrow, it is desirable to separate the early broods of the breeding pairs from the later broods. In the Baroda population, the breeding occurred almost throughout the year, a breeding pair often changed the next-box between successive breeding, and the broods of individual females, in most cases, could not be arranged in a chronological order. We, therefore, assigned the broods studied by us to different months. The broods were assigned to a particular month by using the following procedure. The entire study period was divided into successive 5-day periods. The clutches which were started during a 5-day period were presumed, for the present purpose, to have started on the last day of that (5-day) period. On this basis, for example, the clutches laid between 31st January and 4th February 1969 were lumped with other clutches of February 1969.

Breeding of individually marked birds :

A limited number of females ringed with combinations of coloured rings and serially numbered aluminium rings, were watched and all their breeding attempts were carefully recorded.

STUDY AREA

Baroda (Long. 73° 13′E, Lat. 22° 18′N) is about 31 to 40 metres above sea level and is surrounded by flat country. The campus of the M.S. University of Baroda, where these studies were carried out, is located on the outskirts of Baroda. The campus is interspersed with gardens, sports fields and patches of unused land and is surrounded by residential areas and shopping centres. There is also some farmland close to the study area.

CLIMATE IN STUDY AREA

The following description of the weather during our study period (1969-1973) is based on the meteorological data collected by the meteorological observatory of M. S. University, Baroda.

Summer (February to May) :

(1) *February :* February is a transitional period between the winter and summer. To a limited extent it is comparable to the spring in the temperate region. The daily range in temperature was large. The days were warm ; the maximum daily temperature ranged from about 22° to 39°C. The nights were cool, the daily minimum temperature ranged from about 6° to 22°C. Cloudy weather prevailed occasionally and it drizzled sometimes. The monthly rainfall, however, was negligible and never more than 2 mm. The mean relative humidity during this period was between 57 and 67%.

(2) *March to May :* The nights were usually warm and days hot. The daily minimum temperature did not drop below 11° C, the daily maximum temperature was always above 29°C and went up as high as 46° C. The sky was always clear, except in May when sometimes it became cloudy. This was a very dry period. The total rainfall during the period was never more than 11 mm. The monthly means of relative humidity were between 44 and 71%. The relative humidity during some days dropped as low as 15%.

Monsoon (June to October) :

(1) *June to September :* The daily variation in temperature was usually small. The air temperature at any time was between 15 and 44° C. The average rainfall during this period was 956 mm. The rainfall/month ranged from 22 mm. to 565 mm. The monthly means of relative humidity were between 58 and 92%.

(2) *October :* October is a transitional period between the monsoon and winter. The daily range in temperature was usually wide. The days were warm and the sky was usually clear. Though during this month there was no significant rainfall, the humidity was high. The rainfall was recorded only in 1970 (34 mm). The mean relative humidity in any year was between 55 to 87%. The air temperature at any time was between 15 to 41° C.

Winter (November to January) :

This was a cool dry period. The daily minimum temperature was always below 24°C and dropped on certain days as low as 5° C. The daily maximum temperature was always above 24° C and below 39° C. The relative humidity was on the whole moderate. Monthly means of the relative humidity ranged from 60 to 68%. The sky was clear and rainfall rare.

Annual variations :

Physical features of the climate showing profound annual variations were precipitation and consequently the relative humidity.

The rainy season in Baroda has a tropical regime as it rains during the long days of the year. The average annual rainfall is about 940 mm, and most of it is recorded between June and September (based on the record of last 30 years). However, actual duration of the rainy season, amount of rain during the season and number of dry months may vary from year to year, and these variations have important ecological implications.

Annual distribution of dry periods can be clearly illustrated through ombrothermic diagrams. The ombrothermic diagrams given in Fig. 1 show mean monthly temperature and rainfall plotted according to the system adopted by Walter and Leith (1960-1967). In the diagrams, the amount of precipitation and temperature stand in fixed proportion to each other ; ten degree centigrade corresponds to a precipitation of twenty millimetres. Using this proportion Glaussen (as quoted by Golly and Leith 1972) has established for the mediterranean region a strictly arid period to prevail as soon as precipitation goes below the temperature curve, and a humid period as soon as precipitation exceeds temperature.

Some more information about the moisture status of the monsoon months during the study period is given in Table 1. In the table, humid period is sub-divided into semi-dry, humid and perhumid periods.

In all the years of these studies, January to May and October to December were the dry periods (Fig. 1). In addition to these, September was also a dry month in 1972 (Fig. 1 ; Table 1). According to the classification of climatic regimes by Bagnouls and Glaussen (1957), the climate was semi-arid (=9 to 11 months of the year dry) in 1972, whereas in the other years (1969 to 1971 and 1973) the climate was sub-humid (=5 to 8 months of the year dry). Considering the amount and distribution of rainfall, the years 1969, 1970 and 1973 had 'good' monsoon, 1971 had a 'moderate' monsoon and 1972 was the year of 'drought'.

VEGETATION IN STUDY AREA

Baroda is part of a thickly populated and highly industrialised region of Gujarat State. Most of the land which at one time was covered by dry thorny forest, has either been brought under the plough or used for construction of roads, factories and residential buildings. With the result, the natural vegetation exists only in the form of a few relict communities in the remote corners. In such a biotically disturbed area, the weed flora of cultivated plots, ruderal flora of waste-land and hedge flora occupy positions of prime importance and form the most conspicuous aspects of vegetation.

The vegetation in general has two growing seasons in Baroda, one in the monsoon and the other in summer. However, the pattern of growth of individual species tends to vary in that the peak biomass may be produced in the monsoon, winter or summer, or even twice a year. The start of monsoon in June, marks a rapid growth period of vegetation in general, the beginning of preponderance of the annuals and sowing of the monsoon crops of millets and cotton in the farmland. A wide variety of plants flower and fruit from July to September. With the withdrawal of the monsoon in October, the annuals start drying up, plant litter consisting of leaves, flowers,

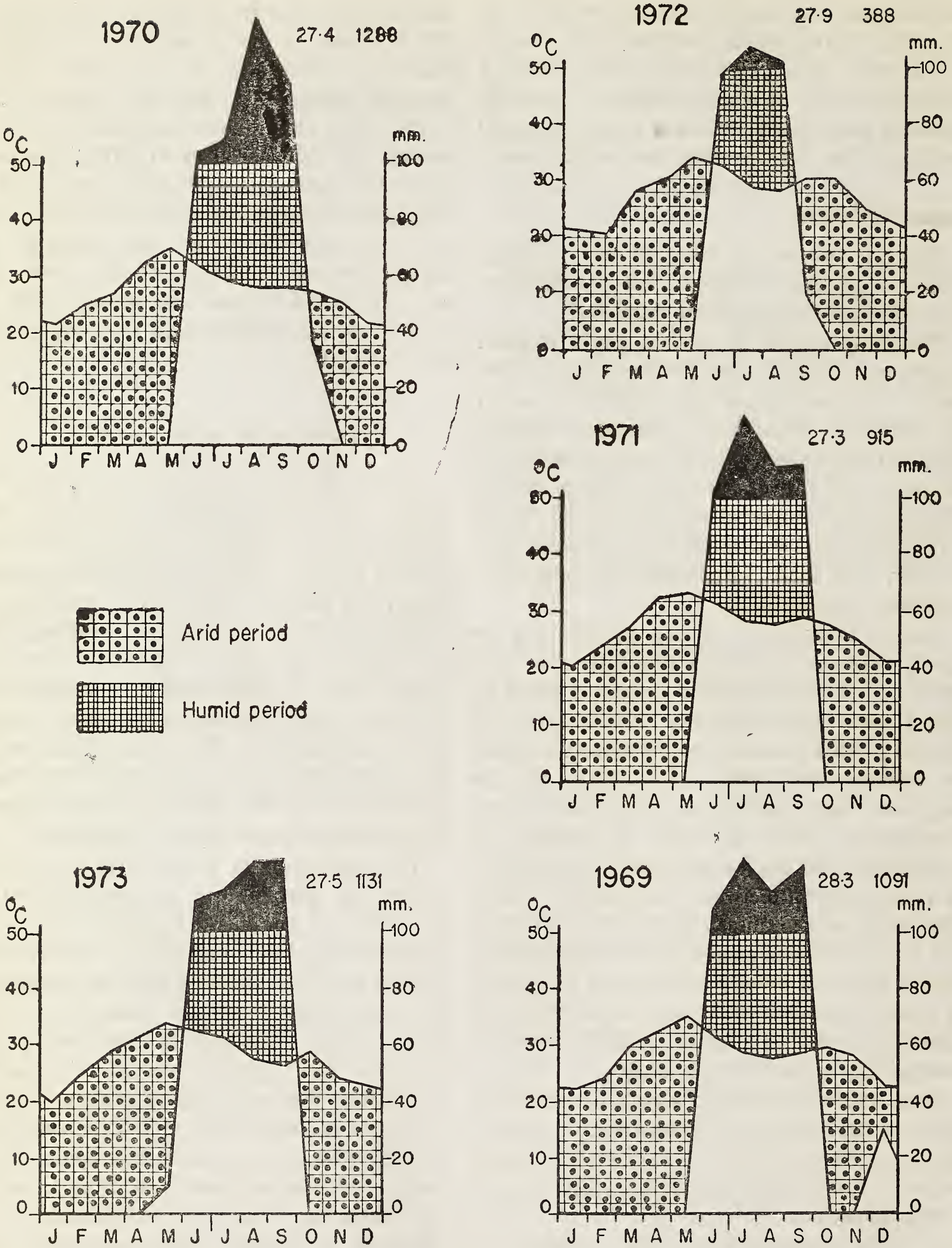

Fig. 1. Climate of Baroda in different years during the study period (1969 to 1973). In each diagram, the year is indicated on upper left corner and the mean annual temperature in degree centrigrade and annual precipitation in mm in the upper right corner. All diagrams are designed on a uniform pattern. Monthly means of temperature and precipitation are drawn as curves; the temperature is in degree centigrade and precipitation in mm. Precipitation above 100 mm is printed in the scale 1 : 10 and marked in black. See text, for further details.

TABLE 1

MOISTURE STATUS OF THE MONSOON-MONTHS IN DIFFERENT YEARS*

	1969	1970	1971	1972	1973
June ..	Perhumid	Humid	Humid	Semidry	Perhumid
July ..	Perhumid	Perhumid	Perhumid	Perhumid	Perhumid
Aug. ..	Perhumid	Perhumid	Perhumid	Subhumid	Perhumid
Sep. ..	Perhumid	Perhumid	Perhumid	Dry	Perhumid
Oct. ..	Dry	Dry	Dry	Dry	Dry

**Note.*—The moisture status for a month is categorised by the following formulae, where P stands for the monthly precipitation in mm and T stands for the monthly mean temperature in degree centigrade :

Dry = $P \leq 2T$
Semidry = $P > 2T$ but $\leq 3T$
Subhumid = $P > 3T$ but $\leq 4T$
Perhumid = $P > 4T$ but $\leq 5T$
Humid = $P > 5T$

fruits and seeds, starts accumulating on the ground and the monsoon crop in farmlands is harvested. In November, the winter crop of wheat and legumes is sown. Rate of production of the natural vegetation is on the whole low in the winter. With the end of winter in February, the leaf fall of deciduous trees starts and is completed by April. A number of trees and other perennial vegetation enter into another period of growth, they sprout new leaves, flowers and fruits between February and April. The weather condition and soil moisture in earlier part of the summer seem to favour germination and emergence of some species of perennial grasses. During the extremely hot dry conditions in the later part of summer, however, vegetation growth is minimum.

In several places in the university campus, where the plots of gardens are regularly watered, moisture is not a limiting factor for the plant growth during dry periods. However, during the period following a ‘ poor ’ monsoon, the water supply in the campus tends to deplete, so that even in the garden plots a drought situation prevails.

BREEDING PATTERN

The percentage of clutches laid by the sparrow in every month is illustrated in Fig. 2. The breeding occurred in every month of the year. The laying pattern during the summer (February to May) was about the same every year ; the pattern was unimodal, the peak having been reached in March-April. During the monsoon, however, the laying pattern varied from year to year ; it was unimodal in some years and bimodal in others.

The number of days in a month the fresh clutches were started is precisely known for the period between 1970 and 1972 (when the nest-boxes were checked every day), and the relevant data are given in Table 2. The days on which the fresh clutches were started were very few or none in January ; the number of days increased in February and maintained a peak level in March, April and May. Thereafter, between June and November, the days on which

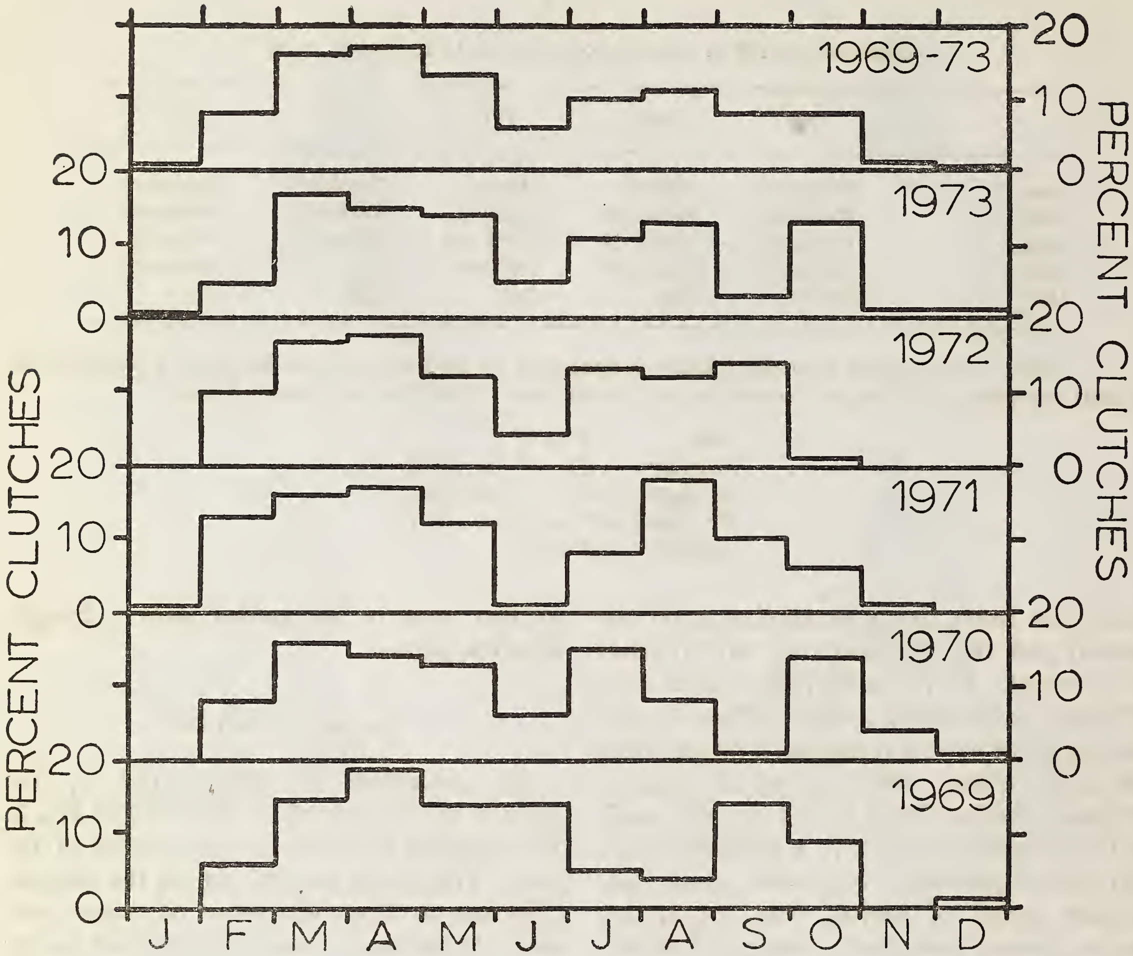

Fig. 2. Relative distribution of clutches started by the sparrows in different months during 1969, 1970, 1971, 1972, 1973 and 1969 to 1973.

clutches were started varied in number from month to month during the same year, and for the same month in different years. There were very few days on which the fresh clutches were started in December.

Though the number of nest-boxes examined and the number of sparrow pairs estimated to have been breeding in the study colonies did not change significantly, during 1970 to 1972 the number of days on which the clutches were started varied from 171 to 193 in different years (Table 2). On an average, 176 days on which fresh clutches were started were mainly spread over a period of nine months from February to October.

A generalized breeding pattern that emerges is that the breeding changed from continuous breeding to restricted breeding and then to sporadic breeding during the course of a 12 month period. The breeding was continuous from about February to May, largely restricted to certain peak periods during June to October

TABLE 2

THE NUMBER OF DAYS ON WHICH FRESH CLUTCHES WERE STARTED IN THE SPARROW COLONIES.

Month	Total number of days fresh clutches started			
	1970	1971	1972	Average
January ..	0	2	0	1
February ..	13	19	15	16
March ..	28	28	31	29
April ..	28	26	29	28
May ..	26	23	24	24
June ..	17	3	6	9
July ..	24	17	18	20
August ..	16	27	22	22
September ..	6	18	17	14
October ..	23	7	3	11
November ..	11	1	0	4
December ..	1	0	0	0
Total ..	193	171	165	178

and sporadic or irregular during November to January. Viewing these observations in the light of seasonal changes in the weather described earlier, some degree of correlation between the breeding pattern of sparrows and environmental changes becomes obvious. During the course of a year, about 50 to 58% of the clutches were laid in the four months of summer, about 41 to 46% clutches in the five months of monsoon and 0 to 5% in the three winter months (Table 3). The birds bred on most of the days in summer (almost all the days in March, April and May); relatively more clutches recorded in the middle of summer (Fig. 2) may possibly be attributed to the late starting younger birds (Seel 1968) having joined up the early-starting older birds at this time in breeding. The breeding pattern during the summer was almost identical in different years and this is correlated with the fact that the same pattern of environmental changes occurred during every summer. It grew progressively warmer after February. In April-May, the solar radiation and heat was intense and the birds reduced their daily activities during the middle of the day; this was partly compensated by the increased feeding hours. In the monsoon, however, there was a great degree of instability in the environment. The weather changed from month to month the dominant variable factor having been the rainfall, and also the days suitable for breeding and the intensity of breeding changed from month to month. The amount of rainfall, air temperature and humidity, and presumably the biotic factors as a consequence, changed in the monsoon of different years. Correlated with this the intensity and pattern of breeding in monsoon was conspicuously different in different years (Fig. 2). In the winter, when the mean air temperature was relatively low and the days were relatively shorter, the breeding intensity was also low; the earlier part of winter (November) was exceptional in that during this period significantly more clutches were laid in some years than in the others (Fig. 2).

Breeding season :

The sparrows bred in every month, but intensive breeding involving a sizable part of the population occurred only during a part of the year ; on the average about 98% clutches were laid during the summer and monsoon (Table 3). The breeding, therefore, is seasonal in a way, and it is possible to demarcate the breeding season. After a certain date in February, when we started recording the first egg of at least one clutch per day, or the first eggs of at least five clutches per every 5-day interval, we considered that the breeding season had started. The precise date when the breeding season started could be determined during 1970 to 1972, as in these years the nest-boxes were checked every day. In 1969 and 1973 the start of breeding season was approximately determined by calculating the dates when the earliest clutches of the season were started. In September-October, when the laying stopped, or when the starting of fresh clutches became irregular events, we presumed that the breeding season had ended. The precise, or the estimated date when the last clutches of the season were started was the date on which the breeding season was presumed to have terminated. In 1970, a considerable number of clutches were recorded in November (Fig. 2), but, these were started at irregular intervals and were, therefore, considered to have been laid outside the breeding season.

The timings of the breeding season in different years were 25 February to 21 October in 1969, 13 February to 26 October in 1970, 12 February to 29 September in 1971, 20 February to 15 September in 1972, and 15 February to 30 October in 1973. The date for termination of the season was more variable than the date of start ; the difference between the earliest and the latest dates for the start of the breeding season was only 13 days while that between the earliest and the latest dates for termination of the season was 45 days.

Breeding and inter-breeding periods :

After the start of the breeding season, the breeding was continuous until May, but June to October it was restricted to one or two peak periods only. With the result, the breeding season could be divided into breeding periods. A breeding period

TABLE 3

SEASONAL DISTRIBUTION OF CLUTCHES IN PERCENTAGE

Year	Total No. of clutches	Percentage clutches		
		Feb.-May	Jun.-Oct.	Jan., Nov. and Dec.
1969 ..	375	53.9	45.6	0.5
1970 ..	402	50.5	44.5	5.0
1971 ..	368	58.2	41.0	0.8
1972 ..	365	57.3	42.7	0.0
1973 ..	346	52.3	45.4	2.3
All years combined ..	1856	54.4	43.9	1.7

Table 4

Duration of the breeding periods

Year	Breeding periods—dates
1969	(1) 25 February to 8 July (2) 27 August to 21 October
1970	(1) 13 February to 2 June (2) 26 June to 16 August (3) 30 September to 26 October
1971	(1) 12 February to 29 May (2) 12 July to 1 September (3) 16 September to 29 September
1972	(1) 20 February to 9 June (2) 14 July to 15 September
1973	(1) 15 February to 2 June (2) 12 July to 31 August (3) 30 September to 30 October.

(PB) is the period of intensive breeding. In practice, this was a period during which we found at least one clutch having been started almost every day. The timings of breeding periods in different years are given in Table 4. Between the two successive breeding periods, there was a distinct interval of time, the inter-breeding period (PIB), when very few clutches were laid (Table 5). In every breeding season one or two inter-breeding periods occurred between the end of May and September. The timings of inter-breeding periods varied in different years.

The total duration of inter-breeding periods varied considerably from one breeding season to the next. The total duration of breeding periods, on the other hand, remained more or less the same in different breeding seasons (Table 6).

Aseasonal breeding :

Breeding outside the breeding season is termed as aseasonal breeding. Some aseasonal clutches were laid occasionally in January. Several aseasonal clutches were recorded for February in the year 1969 and 1972 when the breeding season started late ; these clutches were presumably laid by some early-starting birds. A variable number of seasonal clutches appeared after the breeding season terminated in September-October. 2 to 5% clutches every year were aseasonal clutches.

Breeding pattern of individual females ;

Since the breeding season is long and divided into several breeding periods, it is necessary to ascertain whether the same female breeds in different breeding periods. The monthly distribution of clutches laid by the ringed female sparrows is given in Fig. 3. The figure is based on 16 annual breeding records of ringed females. In the figure, each block represents a clutch laid by a particular female in a particular month ; all the clutches laid by a female during the course of a year, bear the same number, but the successful and unsuccessful clutches are

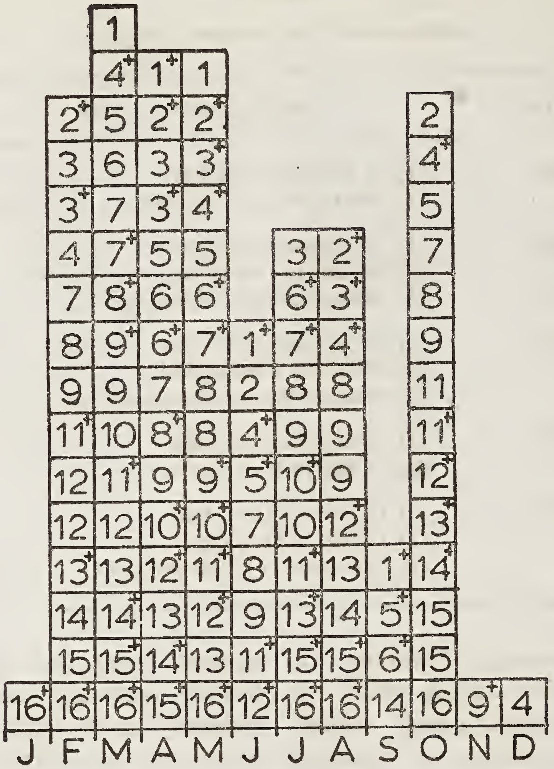

Fig. 3. Monthly distribution of the clutches started by individual ringed females. Each block represents a clutch. All the clutches laid by a female during the course of a year bear the same number. A successful clutch is designated by a cross.

distinguished by suitable symbols. Numbers 1 to 6 stand for the records of six females that bred during 1969, 7 to 14 for eight females during 1970, and 15 and 16 for two females during 1971. 2 and 7, 3 and 8, 5 and 9, 11 and 15, or 13 and 16, is a set of numbers that represent the records of the same female breeding in different years.

It is obvious from the figure that (1) the breeding pattern of individual females corresponded with the breeding season of the population (described earlier), and that (2) the same female which laid several clutches during the breeding season, bred aseasonally outside the breeding season as well.

NUMBER OF CLUTCHES/FEMALE/YEAR

An estimate of the number of clutches/female/year is obtained by dividing the total number of clutches laid during a year by the maximum number of females nesting at one time during that year. A female sparrow in Baroda population is estimated to have laid on the average 6.4 to 7.4 clutches per year (Table 7). It must be pointed out that the maximum number of females nesting at one time during the year is only a minimal estimate of the total number of breeding females. The estimate of 6.4 to 7.4 clutches/female/year is therefore an overestimate.

TABLE 5

INTER-BREEDING PERIODS

		First PIB	Second PIB
1969			
Duration : dates and no. of days	..	9.VII-26.VIII 49 days	—
No. of clutches laid during PIB	..	8	
1970			
Duration : dates and no. of days	..	3.VI-25.VI 23 days	17.VIII-29.IX 44 days
No. of clutches laid during PIB	..	11	7
1971			
Duration : dates and no. of days	..	30.V-11.VII 43 days	2.IX-15.IX 14 days
No. of clutches laid during PIB	..	3	3
1972			
Duration : dates and no. of days	..	10.VI-13.VII 34 days	—
No. of clutches laid during PIB	..	2	
1973			
Duration : dates and no. of days	..	3.VI-11.VII 39 days	1.IX-29.IX 29 days
No. of clutches laid during PIB	..	12	3

TABLE 6

TOTAL DURATION OF BREEDING SEASON AND THE BREEDING AND INTER-BREEDING PERIODS IN DAYS, IN DIFFERENT YEARS

Year		Total duration in days		
		Breeding season	Breeding periods	Inter-breeding periods
1969	..	238	189	49
1970	..	255	188	67
1971	..	229	172	57
1972	..	208	174	34
1973	..	257	189	68

TABLE 7

AN ESTIMATE OF THE AVERAGE NUMBER OF CLUTCHES LAID BY A FEMALE SPARROW IN DIFFERENT YEARS

		1969	1970	1971	1972	1973
(*a*) Total no. of clutches	..	375	402	368	365	346
(*b*) Maximum no. of females nesting at one time	..	56	54	53	57	51
(*c*) Average no. of clutches/female/year (a/b)	..	6.7	7.4	6.9	6.4	6.8

The estimate mentioned above is only slightly higher than the number of clutches laid by a limited number of ringed females observed by us. In 1969, six ringed females laid on the average 6.16±0.75 clutches/female; in 1970, eight ringed females laid on the average 7.05 ±1.85 clutches/female; in 1971, 2 ringed females laid 7 clutches each. Out of these ringed females, two females contributed 6 successful clutches/female/year, whereas the other two, four, six and two females respectively contributed 5, 4, 3 and 2 successful clutches/female/year. The average number of successful clutches raised by a ringed female during the course of a year was 3.75. The interval between the successful clutches (interval between the first eggs of two successive clutches, where the earlier clutch is successful; Seel 1968) was 38±5 days (averege and standard deviation for 25 cases of the ringed females) in the summer. The interval was relatively longer and more variable in the monsoon.

REGULATION OF BREEDING

Start of breeding season:

No clutches were started in January, except in 1971 and 1973, when two and one clutches respectively were laid in January. Apparently January was not suitable for breeding. It was the coolest month every year, except in 1972 when February was the coolest month (Table 8).

The earliest clutches in February appeared when the air temperature started rising (Figs. 4 to 8). Table 8 gives the dates when the earliest clutches in February were laid. In 1969, 1971 and 1972, the early clutches were followed by clutches that appeared at irregular intervals until the breeding season started; altogether 4 to 10 (aseasonal) clutches were started in February before the breeding season commenced in these years. In February of 1970 and 1973, the breeding season started abruptly in that the event was not preceded by the laying of any aseasonal clutches.

The starting of regular breeding, as it has been explained earlier, is considered to be the commencement of the breeding season. After reviewing the daily climatic factors, we gathered that a drop in the air temperature in February may delay the commencement of the breeding season. In 1970, 1971 and 1973, the breeding season started relatively early, between 12th to 15th February. During these years, the mean temperature in February was 2.4 to 3.7° C higher than that in January, and the third week of February was relatively warmer, with the mean temperature between 24 to 26° C (Table 8). In 1969 and 1972, the breeding season started relatively late. In 1972, February was cooler than January the temperature having dropped considerably in the second week of February (Table 8). In 1969, the mean air temperature, after an initial rise in the first week of February, registered a substantial drop to about 21° C on the 16th, so that the mean temperature of February was only slightly higher (by 1.5° C) than that of January and the third week of February was cooler than the preceding week (Table 8).

In birds, the rapid increase in the growth of the ovum resulting in ovulation, starts about 5 to 7 days before the ovulation and some appropriate proximate factors are presumed to be necessary to trigger this process of rapid enlargement of the ovum. It has been found in a wide variety of birds that weather condition for a period of about 5-7 days before the egg laying may be the proximate factor for the laying. Seel (1968) concluded from his studies that the changes in the laying activities of the House Sparrow occurred about four days after the changes in air temperature. In the light of these, we calculated the average daily mean temperature for a 5-day period preceding the start of the breeding season, in different years (Table 8). Every year, except in 1972,

TABLE 8

THE STARTING OF THE BREEDING SEASON

	1969	1970	1971	1972	1973
Date—the first clutch laid in Feb. ..	11	13	5	5	15
Date—the regular breeding started in Feb. ..	25*	13	12	20	15*
Average air temp. in °C for a 5-day period prior to the day the regular breeding started ..	24.7	24.1	23.9	20.2	25.3
Average air temp. in February in °C					
First week	22.0	20.1	20.6	21.1	22.2
Second week	25.2	23.8	22.5	19.3	24.6
Third week	23.6	24.0	24.6	21.7	25.7
Fourth week	25.1	25.2	23.8	22.3	27.0
Entire month	23.9	25.0	23.0	21.0	24.8
Average temp. in °C for months preceding February					
January	22.4	21.3	20.6	21.5	20.3
December	22.7	22.6	21.5	21.5	22.9
November	27.4	27.4	24.5	24.6	26.0

*Approximate date.

the mean daily temperature for a 5-day period prior to the onset of the breeding season was 24 to 25° C. In 1972, when the mean temperature in any week of February was only between 19 and 22° C, the breeding season started late and the average temperature during a 5-day period preceding the commencement of the breeding season was relatively lower (20.2° C). This indicates that the temperature threshold for egg-laying may decline if the onset of the breeding season is delayed. A declining temperature threshold with the passing of spring was illustrated in other species of birds by Nice (1937) and Kluijver (1951). Seel (1968) indicated the existence of a similar phenomenon with respect to the breeding of the House Sparrow.

In the Baroda population, just as in other northern populations, the breeding tends to occur when the winter ends and the air temperature starts rising. The breeding season commences when the temperature reaches about 24 to 25° C in Baroda and 10° C in Oxford (Seel 1968). Seel (1968) suggested that 'laying is adapted to begin at a particular air temperature because at lower air temperature the adult would have insufficient energy available to produce and incubate a clutch.' Several authors consider the air temperature less suitable as a start-timing mechanism for breeding season in birds in general because of its great unreliability and the frequent short-term fluctuations (Immelmann 1972). It is possible that a sharp rise in temperature may have been more effective than temperature in itself (Lofts and Murton 1966). A flush of vegetation growth and increased activity of insects that follow a rise in temperature may have an immediate positive effect on breeding.

Timings of the inter-breeding periods :

We have seen earlier that during each breeding season there were one or two inter-breeding periods, and that during an inter-breeding period, the breeding was negligible, only a few clutches having been laid in the beginning or end of an inter-breeding period (Table 5 ; Figs. 4 to 8).

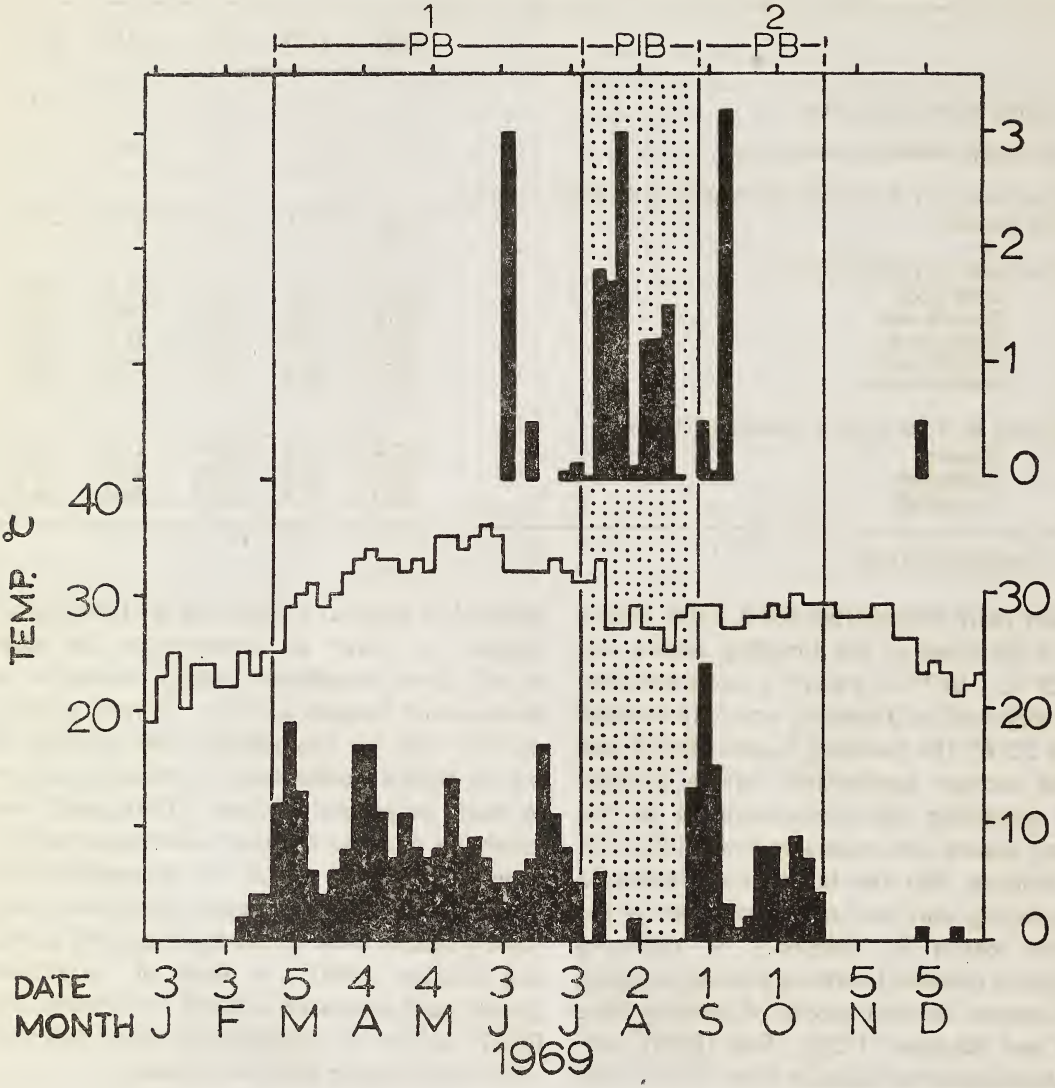

Fig. 4. Histogram showing the number of clutches started (bottom), mean daily temperature (middle) and rainfall (top) per five-day interval, in 1969. Breeding periods (PB : also numbered) and inter-breeding periods (PIB ; dotted areas) are demarcated by thin vertical lines.

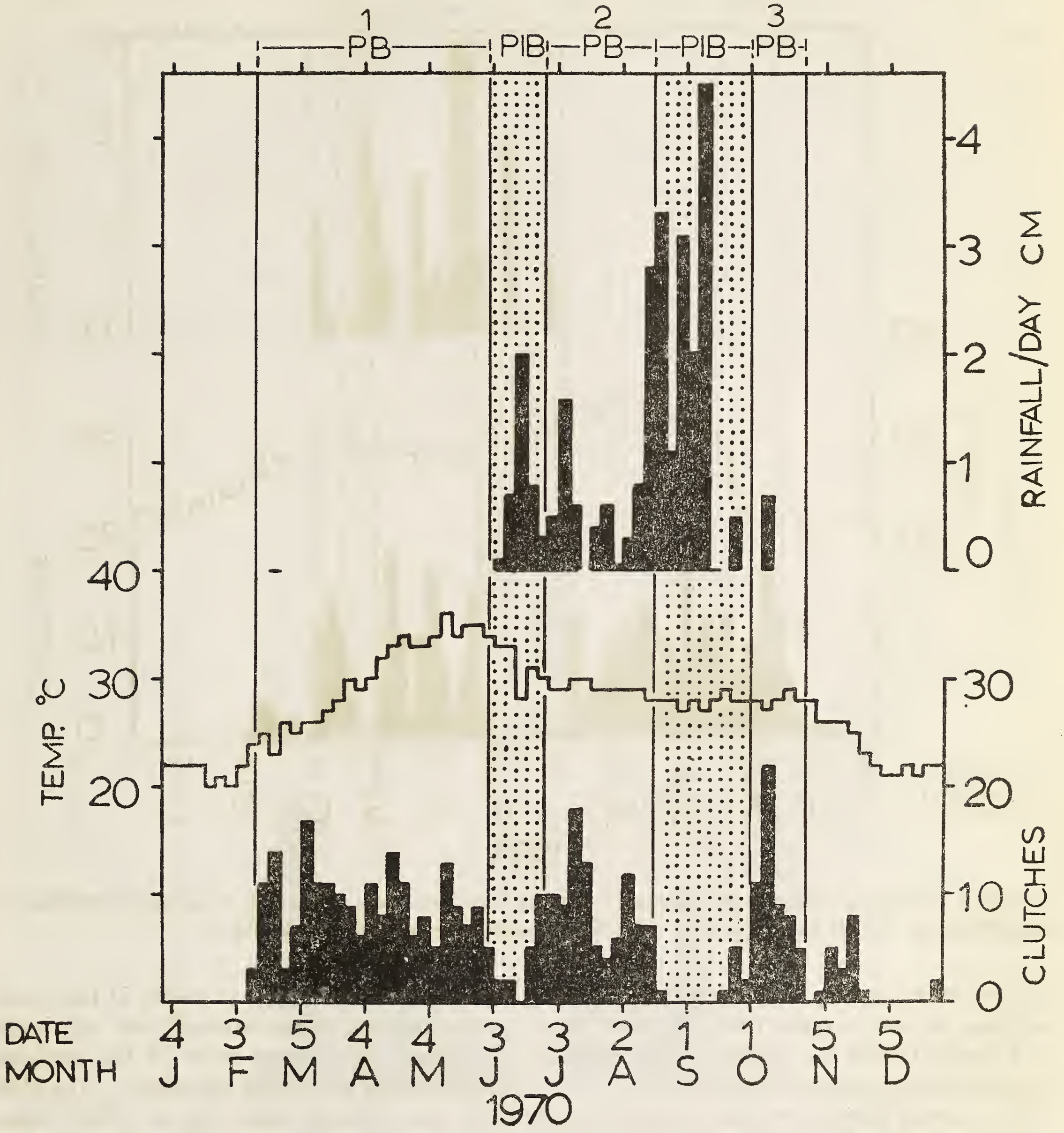

Fig. 5. Histogram showing the number of clutches started (bottom), mean daily temperature (middle) and rainfall (top) per five-day interval, in 1970. For further explanation, see legend under Fig. 4.

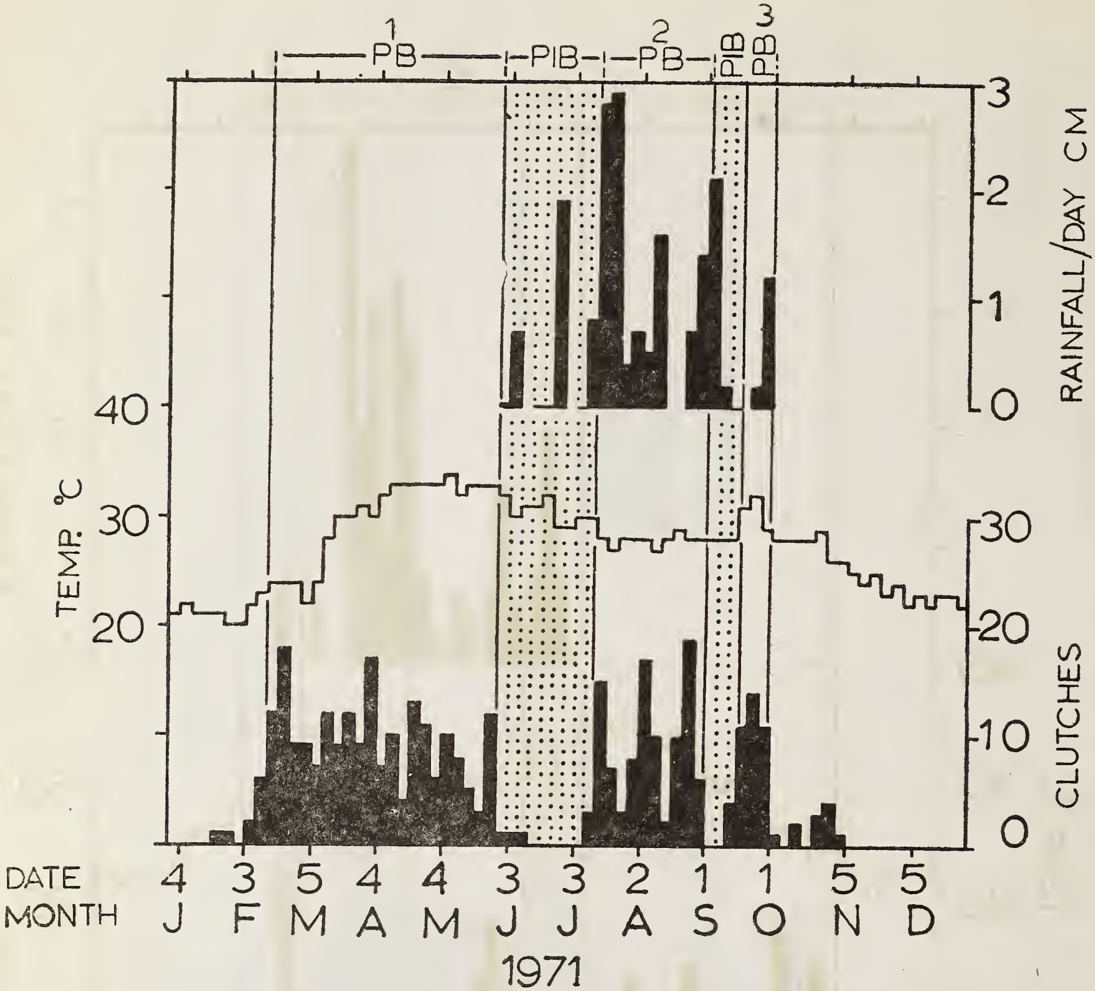

Fig. 6. Histogram showing the number of clutches started (bottom), mean daily temperature (middle) and rainfall (top) per five-day interval, in 1971. For further explanation, see legend under Fig. 4.

We witnessed during our studies eight inter-breeding periods varying from 14 to 49 days in duration (Table 5). Each of these periods coincided with a period of bad weather.

The weather during the inter-breeding period was characterised by heavy rain, a drop in air temperature (Fig. 4 to 8) and reduction in sunshine hours because of the cloudy weather. The dust-storms or thunder-storms also occurred during this period. The sparrow pairs that were not attending eggs or chicks in their nest, visited their nests less frequently and only in the mornings. They spent most of the available time foraging away from the colony. The birds that were already with eggs or chicks when an inter-breeding period started, continued to attend their nests.

The coincidence of an inter-breeding period with a long spell of rain and cloudy weather is indicative of the fact that the extreme rainy weather had adverse effects on breeding. The adult food as well as the nestling food might have been difficult to find during a greater part of the inter-breeding period. During a long spell of heavy rain, the rain itself would decrease the mobility of the birds, water-logged ground would make it difficult for the adults to find food and decreased light hours as a result of cloudy weather would restrict the feeding hours. Under such conditions, the birds would spend all the available time for foraging to meet their metabolic needs and to store the surplus energy which could be more profitably used for breeding when the weather conditions improve. Most of the adults, during these periods, had been without eggs or young and were feeding away from the colony. The fact that the birds laid relatively heavier eggs in bigger clutches when they resumed breeding after an inter-breeding period (Naik and Mistry, unpublished), indicates that the birds did build up an energy reserve sometimes during the period. The pairs which already had eggs when the inter-breeding period started, apparently managed to find enough food near the colony because such birds were very few and faced reduced competition for feeding near the colony.

The inter-breeding period as a break in

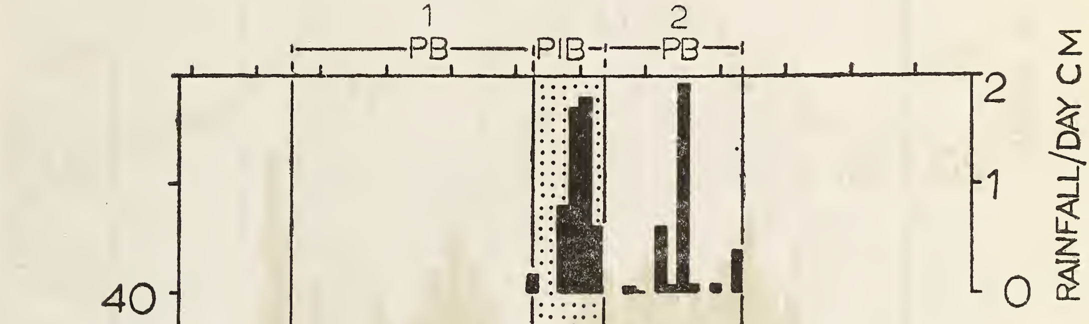

Fig. 7. Histogram showing the number of clutches started (bottom), mean daily temperature (middle) and rainfall (top) per five-day interval, in 1972. For further explanation, see legend under Fig. 4.

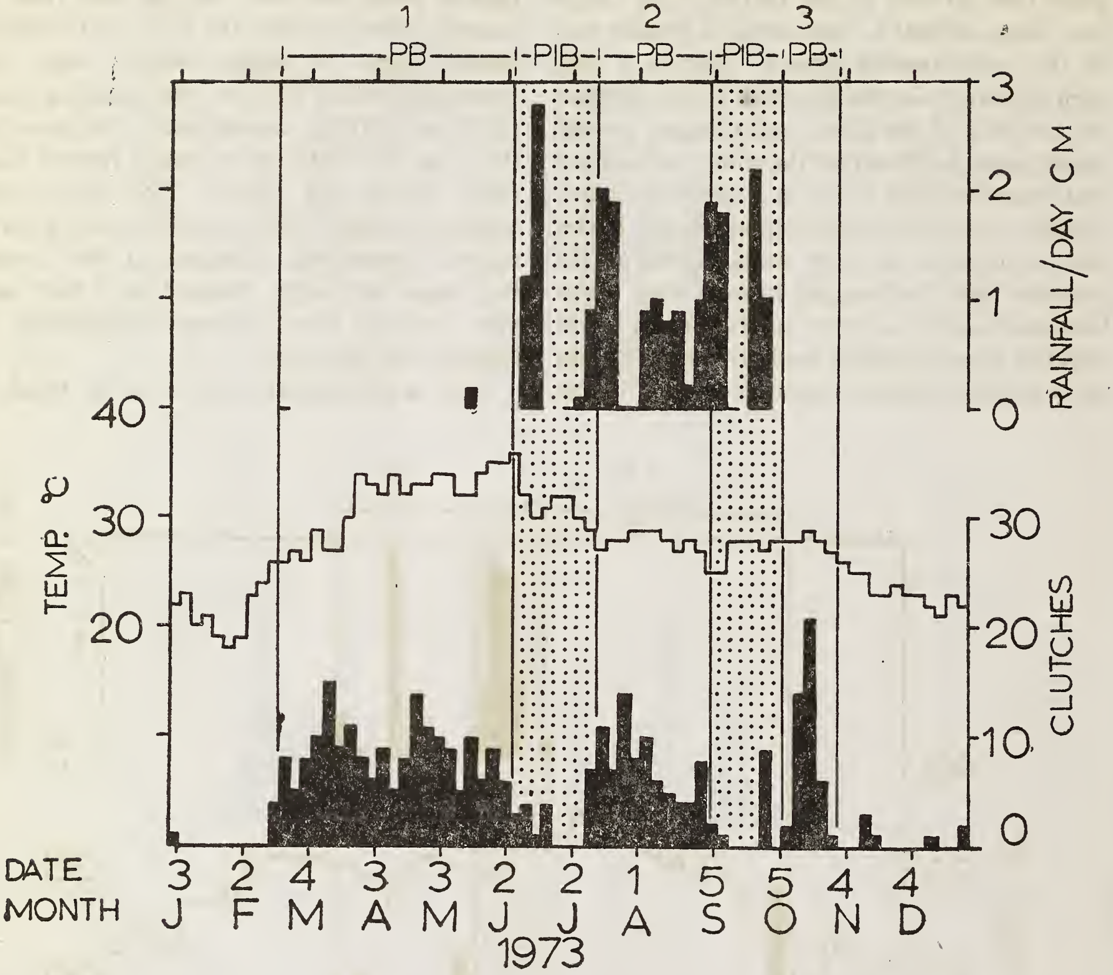

Fig. 8. Histogram showing the number of clutches started (bottom), mean daily temperature (middle) and rainfall (top) per five-day interval, in 1973. For further explanation, see legend under Fig. 4.

reproduction activity in the midst of the breeding season, is certainly adaptive. An inter-breeding period, which staggers the breeding, provides the birds a temporary relief from the reproductive stress. The stress should build up because of the continuous breeding, and some relief from the stress during the breeding season may have a positive effect on the reproductive efforts made by a bird during the season.

Number of clutches laid by a female :

The average number of clutches laid by a female, as we have seen earlier, vary in different years. For an analysis of the causal mechanism behind this, we regrouped the data in Table 9. In the table, a year is divided into a period of five months before monsoon (January to May) and another period of seven months covering the monsoon and post-mon-

Table 9

The average number of broods/female before, during and after the monsoon and the rainfall in different years

Year		Total rainfall (mm)	Average number of broods/female	
			Period before monsoon : January-May	Monsoon and after monsoon : June-December
1968	..	560	—	—
1969	..	1091	3.6	3.1
1970	..	1288	3.8	3.7
1971	..	915	4.0	2.9
1972	..	388	3.7	2.7
1973	..	1131	3.5	3.2

soon periods (June to December). The monsoon (June to October) and post-monsoon (November and December) periods were grouped together, because the pattern of breeding in the post-monsoon period is primarily determined by the breeding pattern laid down in the preceding monsoon. The table also gives the total rainfall for each year. It may be recalled here that the total rainfall given for each year was almost entirely recorded during the monsoon. The average number of clutches/female during the monsoon and post-monsoon periods of a year is related to the rainfall during the year.

A relationship between the average number of clutches/female during the monsoon and post-monsoon periods and the rainfall during that year is more clearly illustrated in Fig. 9. The regression formula for the curve fitted to the five observations is $y = 3.38430 - 0.02591x + 0.00022x^2$, the correlation coefficient being 0.9952. It is thought desirable to have a quadratic expression instead of a linear one in x for predicting y, because the residual sum of squares for the quadratic fit is 0.005404, whereas that for the linear fit is 0.145902, which is relatively much higher; this is also revealed by the fact that the correlation coefficient for the quadratic fit is higher than that for the linear fit (0.8620). According to the form of curve fitted to the five observations, the number of clutches laid by a female during the monsoon and post-monsoon periods decreases with a decrease in the annual rainfall, until a level of 500 mm rainfall is reached, but, a decrease in the number of clutches is proportionately less than a corresponding decrease in the rainfall (Fig. 9). It seems possible that any further decrease in the rainfall may not correspond with a change in the number of clutches and that the lower-most limit for the number of clutches that a female lays on an average during this period may be about 2.7. There should be an upper limit for the average number of clutches laid by a female between June and December. Such a limit was probably reached in 1970, when the breeding season continued up to the last week of October and a maximum number of aseasonal clutches were laid in November. While we have speculated about a lower and an upper limit for the number of clutches, it must be stressed that the relationship derived between the annual rainfall and the number of clutches laid by a female would hold good only within the observed range of rainfall.

The average number of clutches laid by a female between January and May bears a linear relationship to the amount of rainfall in the previous year (Fig. 10). The regression formula for the curve in Fig. 10 is $y=3.29333+0.00502x$, the correlation coefficient being 0.9693 ; here, it makes no difference whether one chooses a linear or quadratic expression in x for predicting y and therefore a simple linear regression is used.

The above observations indicate that the average number of clutches laid by a female sparrow during a year is dependent upon the amount of rainfall in the previous year, as well as that during the year in question. A possible explanation for this relationship is that the amount of precipitation affects the food supply of the sparrows and the food supply is the most dominant factor, among the factors determining the number of clutches laid by a female in Baroda. Because of ample sunlight and relatively warm weather, the precipitation is known to be the main factor affecting the growth of plants and seed-production in the tropics. During the wet season (monsoon), the amount of precipitation during the season is an effective factor. During the dry season (summer), however, it is the precipitation during the preceding wet season that is effective.

The average number of clutches laid by a female during a certain interval of time would depend upon not only the rate of food supply, but also the number of days favourable for breeding. The breeding, after a less variable start, occurs almost every day in the summer, so that the rate of food supply primarily would influence the number of clutches laid by the female during that season. The number of days on which the sparrows are capable of breeding in the monsoon and post-monsoon periods varies in different years (Table 2), so that the food supply as well as the number of days favourable for breeding would determine the average number of clutches laid by a female during these periods. Here, not only the total

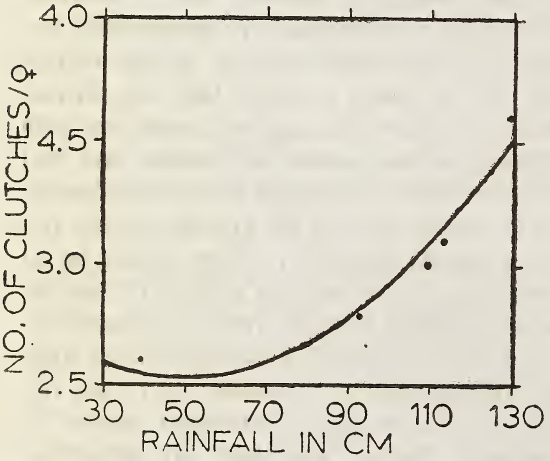

Fig. 9. Relationship between the annual rainfall and the average number of clutches laid by a female during the monsoon and post-monsoon periods.

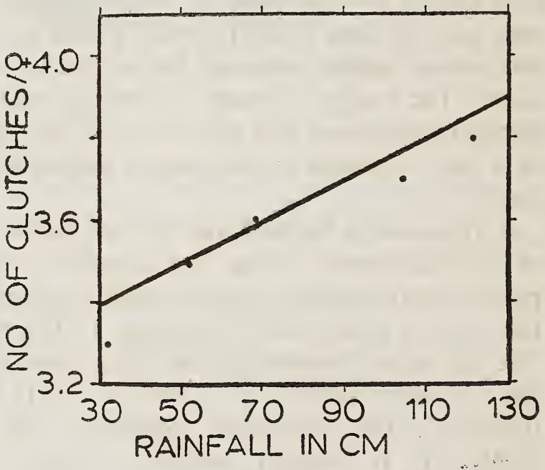

Fig. 10. Relationship between the annual rainfall and the average number of clutches laid by a female during the next year summer.

amount of rainfall but also the pattern of rainfall during the season may be involved. The breeding periods alternate with the inter-breeding periods and the breeding is relatively more synchronized at the population level in the monsoon. Under these conditions, the overall temporal distribution pattern of the breeding and inter-breeding periods, rather than only the total number of days favourable for breeding, may influence the average number of clutches/female. The breeding and inter-breeding periods are largely regulated, as we have seen earlier, by the pattern of rainfall.

Termination of breeding season :

The date on which the breeding season terminated and the total rainfall in different years were as follows :—

1972—15 September, 388 mm ; 1971—29 September, 915 mm ; 1969—21 October, 1091 mm ; 1970—26 October, 1288 mm ; 1973—30 October, 1131 mm. The timing for termination of the breeding season seems to have been related to the rainfall during the year. In a year of ' good ' monsoon, as compared to a year of ' poor ' monsoon, a good supply of food might have been available for a longer period, and the breeding season therefore was prolonged. Apparently, the decreasing food supply had an immediate negative influence on reproduction of the sparrows. Existence of such a mechanism for the termination of breeding season is considered a possibility in several other species of birds also (Dunnet 1955 ; Farner 1967).

Discussion

The avian breeding seasons present a wide spectrum ranging from continuous to restricted breeding season ; a continuous breeding season tends to occur in regions of the world where there is no marked seasonality in the climate and a restricted breeding season tends to occur in the regions with seasonal variations in the environmental conditions (Immelmann 1971). A continuous breeding season for the house sparrow, to our knowledge, has so far not been described, but, it possibly occurs in suitable habitats. The restricted breeding season of the sparrows have been described for the populations in the temperate regions (for example, April to July in England, by Seel 1968) and also in some of the tropical regions (March to July, in Lahore, Pakistan, by Mirza 1972).

Breeding season of the Baroda sparrows represents a stage transitional between the two extremes, the continuous and restricted breeding seasons. The breeding season is long. Its start is well defined and the timing is subjected to only small yearly variations. After the breeding season starts, the breeding is continuous until the end of summer. In the monsoon, however, the breeding occurs during certain well defined periods (breeding periods) only. During the interval of time (inter-breeding period) between the breeding periods, the breeding activities are largely excluded. Such an inter-breeding period may occur once or twice and it tends to prolong the breeding season. The termination of breeding season in the later part of monsoon not only has a variable timing but is poorly defined at least in some years when the fresh clutches keep on occurring sporadically even after the season terminates.

The complexities in the timings of breeding season, as outlined in the previous paragraph, should be taken into account in timing the breeding season accurately. During an inter breeding period, for example, one may believe that the breeding season has terminated, only to find it restarting after a certain interval of time. In the light of this, the existing literature about the breeding season of sparrows in different parts of India needs to be carefully reviewed. All the same, it is apparent from the published literature that timings of the breeding season tend to vary widely in different parts of India. Ali and Ripley (1974) who have summarized some of the general trends in these variations, state that the season extends from March to June in the north, continuing till September or October in central India and extending throughout the year in Southern India. From north to south, the winter tends to be milder and the monsoon tends to be earlier and longer. Apparently correlated with this, the sparrow tends to extend its breeding season at both ends (earlier start and later termination of the season) in the southern parts of India.

It had become possible for our sparrows to lay an unusually large number of clutches (as many as six successful broods/female/year) because they had a long period favourable for breeding and their breeding was not continuous throughout the breeding season, but interrupted by the inter-breeding periods when they were relieved from the reproductive stress and built up energy reserve to make a fresh attempt at reproduction again. In contrast to our sparrows, the sparrows in Oxford during their restricted breeding season laid on the average only 2.1 clutches/year and only some of the pairs made 4 to 5 breeding attempts (Seel 1968). It is interesting to note that the interval between the successful clutches for the sparrows was about the same in Oxford and Baroda. The interval in Oxford was 40 days (Seel 1968) and in Baroda during the summer was 38 days.

A large number of studies made on the breeding patterns of birds have indicated that every species of bird tends to breed at the time of the year when it can raise its young most efficiently (Lack 1954, 1966). Those environmental factors that control efficiency of breeding are called ' ultimate factors ' (Thomson 1950). The most important ultimate factor for nearly all species of birds is the availability of an adequate food supply. Our observations on the breeding pattern of the House Sparrow and some casual observations on the bird's habitat in the study area provide further circumstantial evidences for the above views. From February to May different species of perennial plants shed the old leaves and sprout new ones. Several species of these plants also flower and fruit during this period. Following the flushes of vegetation growth, the blooms of insects and caterpillars keep on appearing. The winter crop of cereals is harvested by the farmers in April-May. Taking advantage of all these, the sparrows breed uninterrupted and raise several successive broods in the summer. A more active period of vegetation growth starts with the monsoon in June, and terminates in August-September just before the end of monsoon. A number of perennial plants flower and fruit from August to October and it is during this period that monsoon crops of cereals are harvested by the farmers. The insect food for the sparrow nestlings is particularly abundant during the monsoon. The food supply and its availability are assured during the monsoon, only if the rainfall during this period is adequate and properly spaced out. This rarely happens in the sub-humid to semi-arid habitat of the sparrows in Baroda. The rainfall during a monsoon has an almost unpredictable pattern and periods of floods and droughts occur. The food supply for the breeding sparrows is also apparently variable and the ' good ' periods may alternate with the ' lean ' periods. Consequently, the breeding of sparrows during the monsoon is interrupted from time to time, and is never continuous as in the summer.

The food supply is apparently adequate even after the breeding season ends in September-October. The post-breeding period, however, is occupied with moulting. Our casual observations indicate that the sparrows start moulting in September-October. When after a ' good ' rainy season the food supply is still exceptionally good, a number of sparrow pairs may breed aseasonally in November. In these birds, some adjustments between the moult and breeding probably occurs ; a variety of adjustments between the moult and reproduction in birds have been described by Stresemann and Stresemann (1966).

The food supply, or its availability, apart from being the most effective ultimate factor, apparently has an immediate influence on egg-laying. Immediate positive effect of an increased or easily accessible food supply on the breeding seems to operate as a timing mechanism for the start of breeding season and the termination of inter-breeding periods. Similarly, immediate negative effect of a decreased food supply seems to time the start of inter-breeding periods and the termination of breeding season. The quality and/or quantity of food supply may influence the time of egg-laying by directly affecting the reproductive physiology of the adult bird. Circumstantial and experimental evidences for the importance of nutritional factors in spermatogenesis and egg-laying are discussed by Marshall (1949), Siivonen (1957), Assenmacher *et al.* (1965), Buhler (1965), Loft and Murton (1966), Lack (1967) and Braithwaite and Frith (1970).

In the tropics, where precipitation is the most important limiting factor for the food supply, the rainfall has a remarkable influence, indirectly through the food supply, on the fecundity of sparrows. A ' good ' rainy season as compared to a ' poor ' one, results in a female sparrow not only laying more clutches during the monsoon and breeding aseasonally in the winter, but also laying more clutches in the following summer.

In the light of the present findings that the pattern of breeding and the fecundity of sparrows show a close relationship with the pattern and amount of annual rainfall, one should expect a wide degree of variations in breeding of the sparrows, correlated with a wide variety of climatic regimes to be found in the Indian sub-continent. Based on the rainfall pattern, four types of regimes are recognised for the Indian sub-continent. These are (1) irregular regime, where rainfall lacks a seasonal rhythm and includes regimes with three or four dry periods in a year, (2) mediterranean regime, where it rains during the short days of the year, (3) bixeric regime, where there are two rainy periods and two seasons in a year, and (4) tropical regime, where it rains during the long days of the year (Meher-Homji 1971). Based on the degree of aridity-humidity, four types of climatic regimes, according to a classification by Bagnouls and Glaussen (1957), occur in the Indian sub-continent and these types are (1) humid, where 0 to 4 months of the year are dry (when the monthly precipitation, in mm, is less than twice the mean temperature, in °C, (2) subhumid, where 5 to 8 months of the year are dry, (3) semi-arid, where 9 to 11 months of the year are dry, and (4) arid, where 12 months of the year are dry. Here is, therefore, a good case for the desirability of having a co-operative study on the breeding of sparrows in different parts of the Indian region.

ACKNOWLEDGEMENTS

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THE AVAILABILITY OF NESTING MATERIALS AND NESTING SITES AS VITAL FACTORS IN THE GREGARIOUS BREEDING OF INDIAN WATER-BIRDS

M. KRISHNAN[1]

(*With five plates*)

INTRODUCTION

In the mid-fifties, I surveyed the old-established Vedanthangal Sanctuary for water-birds in the Chingleput district at the request of the (then) Government of Madras, to recommend measures for conserving and improving the preserve. Over the next two seasons, and part of the third, I visited Vedanthangal each week-end from mid-September to mid-February, to study the main breeding birds, their nesting, and other features of the sanctuary. The flora of the tank bed (during the dry season) in the middle of which the birds had nested for centuries in a grove of *Barringtonia acutangula* trees, and of the surrounding scrub from which they collected the thorny, unarmed, and leafy dry and green twigs for the construction, lining, and periodic replenishment of their nests over the prolonged breeding enterprise (extending over about 3½ months) had also to be studied, and for this I sought the expert help of the wood-anatomist and taxonomist, Dr. B. G. L. Swamy, who was entirely responsible for this valuable floristic assessment, made over two seasons and with the assistance in the field of my son, M. Harikrishnan (now of the Tamil Nadu Forest Department).

My rusty recollections of botany, and less rusty knowledge of the vegetation of the Chingleput district, enabled me to appreciate this floristic assessment, and also to realise that variations in the species of plants from which the different kinds of nesting and nest-replenishment materials were collected are inevitable, since the floristic complexion of the peripheral scrub of different mixed heronries is varied. Nevertheless, it was considered worth while to undertake an independently verified assessment of the plants from which such nesting materials were collected at Vedanthangal. For this purpose, I watched the birds collecting twigs from the peripheral scrub, and tagged those plants which could not be readily identified, and later ascertained their identities (when in flower) with the help of a flora. At the end of the nesting season, 3 representative nests were collected intact, and separately analysed by Dr. Swamy by pickling, sectioning and examining the twig-sections under the microscope and comparison with his extensive labelled collection of slides of south Indian woody plants. He was able to confirm my identifications of the twigs used for nest building (the identification by me had not been disclosed to him) and to add considerably to my list. The result of this study was incorporated, tabulated, in my second report on the sanctuary to the Government. Wishing to append it to this paper, recently I applied to the Tamil Nadu Forest Department for a copy of this technical note, and was informed that my report could not be traced in governmental records. It is still possible to reconstruct this note from Dr. Swamy's notes made at the time he identified the nest-twigs, but this laborious reconstruction has not been attempted in view of the variations already mentioned in the choice of different kinds of nesting and nest-replenishment materials (which, in turn, depend on the kind of material preferred being available in the vicinity of the breeding centre).

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In fact, this elaborate verification of the nesting materials used at Vedanthangal in the mid-fifties (which may no longer be valid even for this sanctuary, considering the near-total denudation of the wild peripheral scrub at Vedanthangal today) is detailed here for a quite different reason. It was this that first made me realise how important a factor to the success of the gregarious breeding of Indian water-birds the availability of the different kinds of nesting materials is, and how little this vital factor has been appreciated in our conservation effort. The last sentence is a compressed and over simplified statement of this factor, which is set out more adequately in the body of this paper, following the introduction.

Since 1956, right up to the present, as opportunity offered I have observed the nesting and the collection of nesting materials by water-birds at other breeding sites, and also the replenishment of their nests by them over the period of their breeding enterprise. An inseparably associated factor, the choice of nesting trees or other nesting locations, has also been studied, and the present paper is based on sustained and sporadic observation over the past 20-odd years in many parts of India. The main nesting colonies at which these observations were made are specified below :

Kerala ;

The Periyar sanctuary. Along the Quilon backwaters.

Tamil Nadu :

Vedanthangal sanctuary.	All 3 in the Chingleput district, the first two (only some 5 mile apart) featuring practically all the birds listed below except for the grey pelican which, however, may also be seen in certain years in one or two pairs. These two preserves are specially notable for their grey herons, night herons and openbills.
Karikili water-bird reserve.	
Dhamal tank.	

Karungulam tank at Kallidaikurichi in the Tirunelveli district, where egrets, darters and a few herons nest atop 2 or 3 tall trees on the bund.

NOTE :—The breeding colony of egrets in planted *Acacia nilotica* clumps in Dhamal tank is no longer there, the trees having been cut down. Night herons, cattle egrets, egrets and pond herons, nesting in many locations in Mylapore, Raja Annamalaipuram, Adyar and some other parts of south Madras, since colonised by men, were also observed.

Andhra Pradesh :

The Aredu pelicanry in the West Godavari district.

The Nelapattu mixed pelicanry in the Nellore district.

Orissa :

A mixed heronry in a mangrove swamp in Bhitar Kanika island.

Karnataka :

The Ranganathittoo sanctuary, near Mysore (Srirangapatnam).

Assam :

The pelicanry near Kaziranga village.

Rajasthan :

The Keoladeo Ghana (Bharatpur Bird Sanctuary) in Bharatpur.

Further, other nesting colonies at small tanks in Tamil Nadu and in Karnataka were also observed. Almost all of them are no longer there. The nesting of birds like the little grebe, also found at mixed heronries, was not observed. The larger water-birds whose gregarious breeding was observed are listed below :—

Little Cormorant
Indian Shag
Large Cormorant
Darter
Little Egret
Median Egret
Large Egret
Cattle Egret
Pond Heron
Grey Heron
Night Heron
Openbilled Stork
Painted Stork
Spoonbill
White Ibis
Grey (Spotted-billed)
Pelican

Basic Factors

The water-birds considered here nest gregariously in crowded colonies. These may be large mixed heronries, as at Bharatpur, Vedanthangal and Ranganathittoo ; or they may be much smaller but still congested colonies limited to 2 or 3 species nesting in a few adjacent trees, as at Karungulam ; or they may be large or small congregations of a single, or of dominantly one, species—for instance, the Aredu and Kaziranga pelicanries and the nesting-trees of night herons in Mylapore and other parts of Madras city.

Many features govern the breeding enterprise of these birds, not all of them instinctive. For example, they get into breeding condition only when an abundant supply of food is available, and since this abundance is seasonal and territorial, and not a transient and haphazard event, the assured supply of food that gets them into breeding condition (a physiological and not an instinctive stimulus) also ensures adequate nourishment for their voracious, demanding and fast-growing young. Even with regard to these seasonal periods of plenty, the extent to which the breeding of these birds is influenced by drastic fluctuations may vary with different species. Early in the forties, the low-lying wastelands and paddy fields of south Madras were gradually built up and converted into Raja Annamalaipuram, and the many nesting-trees of egrets, cattle egrets and night herons in this area were consequently lost. This was followed by unprecedented drought, and it was noticed that while the egrets, obviously affected by the paucity of food in peripheral feeding grounds, did not nest at all, or nested only in noticeably diminished numbers, in the few established nesting trees near Adyar (since cut down), the night herons invaded the most congested parts of Mylapore and nested in such trees as they could find in the compounds of human residences there (one such nesting-tree, used for years till cut down, was in the tiny compound of the Mylapore Police Station), breeding thickly : they, unlike the egrets, were able to find their food supply from the Buckingham Canal and its slushy banks, close by.

It is useful at this stage to consider the extent to which we can be sure of avian instincts, the complex impact of diverse instinctive urges governing the breeding enterprise of these birds. That all these impulses do not have the identical directional slant, and are not narrowed down to particular and unvaried preferences, is a reasonable conclusion, though they may serve much the same ultimate end even when mutually antagonistic. This may be illustrated by two well-known reactions of nesting water-birds : obviously the instinctive attachment of a brooding bird to its nest is sharply in conflict with its instinct of self-preservation when danger approaches the nest closely; on such occasions, frequently it flies away at the last moment, kicking the eggs (or even the hatchlings) out of the nest in its seeming panic flurry. At first sight this may seem a self-destructive reaction, but though it definitely destroys that particular clutch, it may actually help the breeding enterprise as a whole, since the breeding pair, having lost its clutch or brood, is hastened to the next brood. In this note, which is mainly concerned with the importance of nesting materials, such complex inter-reactive compulsions need not be detailed, but it may be said that the accepted view is that these diverse instinctive promptings all tend to be ultimately beneficial to the species and have survival value: otherwise, obviously, urges that are self-destructive would have resulted in the extinction of the species.

Instinct knows no intelligent acceptance of defeat, but only frustration or death when it cannot be fulfilled in some way. It is here that ornithologists have sought, in their desire to keep the distinction between instinct and intelligence clear, to find intermediate terms such as 'intuition' (James Fisher and Roger Tory Peterson: THE WORLD OF BIRDS) which are of debatable validity. The sublimation of an instinctive urge or apprehension is well known in animal behaviour, where displacement activities are recognizable, but the acceptance of substitutes for the nesting sites and nesting materials instinctively preferred (where the environment is entirely natural and rich in its resources) by water-birds is something quite different. Since nesting sites and nesting materials are closely inter-related, the choice of nesting sites by these birds has to be considered, where otherwise they are assured of their breeding needs.

Nesting-trees and other nesting sites

In their gregarious nesting, water-birds are instinctively impelled to choose trees (or other sites) that offer them some security from disturbance and ground predators[1], either by being insulated by water (by their boles being partially submerged as at Bharatpur, Karikili, Vedanthangal and Nelappattu, or by the trees being on small islands in deep water, as at Ranganathittoo) or by their boles being very tall (as at the Aredu and Kaziranga pelicanries, and at Karungulam).

Where such trees are not available or are of limited availability, they may accept substitute nesting locations, food supply and other factors being congenial. Such acceptance of substitute sites may be partial or total, depending on the availability of nesting-trees in particular locations. A few illustrative examples will help to make this point clear, but before going on to them it may be said that among other birds, too, the acceptance of substitute nesting sites where the pristine, natural nesting sites are no longer available is well known. Blue rock pigeons, for instance, nesting originally in caves and sheltered cliffs, have taken freely to the somewhat similar nesting sites provided by old forts and the spires of mosques and temples, even where they are probably truly wild, and not feral atavistic reversions from domesticated stock.

A quite remarkable acceptance of substitute nesting-trees is provided by the pelicanry around the hamlet of Aredu, in West Godavari. In recent years, the birds seem to have abandoned, or are much less regular at, this long-established nesting site. There are no other tall trees here—pelicans like to nest in lofty trees, as at Kaziranga, where they do not have the insulation of water all round as at Nelappattu—and so they used to nest regularly in the palmyra and coconut tops around the hamlet—the last kind of trees one would imagine grey pelicans would choose to nest in! (Plate I, 1). I observed the nesting birds closely here in 1968, and they were very much at home atop the palmyras. The reasons for their giving up this breeding site are probably wholly unconnected with nesting trees, as is explained later in this paper.

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[1] A purely artificial factor that has profoundly influenced the establishment of water-bird breeding sites is the protection offered to them by human countryside sentiment: the major nesting colonies now extant, or known earlier in this century, mainly owed their origin to this, or still owe them to this protection or its substitution by the accord of governmental protection. Vedanthangal provides a fully documented example of this factor.

RANGANATHITTOO

Though less flagrant an instance than the quaintly picturesque sight of pelicans atop palmyras that Aredu offers, the Ranganathittoo sanctuary is a much more significant and multi-faceted example of the acceptance of substitute nesting sites by water-birds. There is a great variety of nesting species, and one can study the transition from what may be termed the orthodox sites in trees to the most extraordinary substitute locations at Ranganathittoo.

Unlike other mixed heronries insulated by water, it is no village tank (Vedanthangal, Karikili) or large, artificially created lake (Bharatpur) that provides the protection, but the deep, fast-flowing Cauveri. At a bend in the river there is a large mixed heronry to be found from July to October-November (taking the vagaries of the monsoon into account) comprising, in the main, the following breeding birds: cormorants of all 3 kinds, the darter, the little, the median and the large egrets, the cattle egret, the pond heron, the openbill, the spoonbill and the white ibis: egrets and openbills are the main features of this sanctuary, and there are only a few pairs of spoonbills. The brief account that follows of the nesting of these birds takes note only of dominant trends and ignores exceptions.

Ranganathittoo is notable in that unlike other mixed heronries, it offers no home-water—the river is the home-water. The feeding grounds are the inundated low flats, paddy fields and minor irrigation canals in the neighbourhood, and nesting commences and ends sooner here than in other water-bird breeding areas the birds beginning to nest with the first heavy monsoon rains in July. They build in a few trees along the river and a few trees on shallow, rocky islands, some of them only a few square metres in area, in the river, and also in the brakes of screwpine along the bank and on the islands, and even in less congenial locations. Further, some of the limited number of trees available, especially the taller ones along the bank, are used not so much for nesting as for roosting—at all sizeable mixed heronries such roosting trees may be found, used during the early part of the breeding season mainly by a number of water-birds (of the same species as those nesting) that have not yet, or not for the season, got into breeding condition, and later briefly both by the breeding birds and their grown young. While the cormorants and darters nest here in trees, as elsewhere, the other birds may also nest in the screwpine and even in sedges.

Openbills and white ibises like to nest in colonies mainly by themselves (though a few other water-birds may also nest on the same trees): at Ranganathittoo also there is such an ‘ openbill-tree ’ on one of the central islands, a *Terminalia arjuna* whose crown has a quite atypical, low, flat spread by the top boughs radiating in a downbent, lateral direction: there are also two lesser colonies of openbills on trees on the islands. But openbills nest also atop screwpine on these islands, as I have not seen them doing anywhere else, building high up the screwpine brakes as other birds nesting in these brakes do not. To the extent of my limited personal observation at this sanctuary, the openbills first build in their trees (they always nest in the same trees) and perhaps those that nest in the screwpine do so because the nesting trees are already occupied by earlier pairs.

The spoonbills nest mainly, or entirely, in the screwpine brakes, building their nests low down near the basal parts of the screwpine and just inside the outer periphery of the brake. They roost in the treetops at times.

White ibises, perhaps, build the most elementary (primitive) kind of stick nests among these birds. Elsewhere it may be noticed that they favour low, flat-topped trees, building their shallow nests close together, the nests often being confluent and forming what may be termed rafts. At Ranganathittoo there are two trees specially favoured by white ibises—in 1968 I saw some nests right atop a screwpine brake, built on the flat top formed by the thick, sword-shaped leaves bending sharply down towards their terminal part. More remarkable, some of the white ibises nest on a small, flat-crowned rock thinly covered with soil and herbage projecting just above the water level, a singularly vulnerable location—I have seen these nests (and their contents) being carried away by the current when the water rose in the river.

Elsewhere, egrets nest in comparatively low trees when they have the insulation of water, not only in colonies by themselves, but also along with cormorants, darters, herons and openbills. *Acacia nilotica* and *Barringtonia acutangula* are trees specially favoured by them: they build fairly low in these trees, but well above the water level. Where they do not have the insulation of water, as when nesting in trees on the banks of tanks and lakes, they prefer tall trees—at Karungulam, for instance, a few tall *Terminalia bellerica* and jamun (*Syzygium*) trees. At Ranganathitoo, however, the majority of the egrets nest, not on trees (where, also, some nest) but in the screwpine brakes, low down and well inside, often along with night herons and cattle egrets (Plate I, 2) : in places, the screwpine is white with nesting and roosting egrets. Moreover, there is a subsidiary island near the island on which the 'openbill tree' (*Terminalia arjuna*) stands, and on this island a thick growth of sedges and grasses fringes part of its outline. Egrets have always nested in this patch, low down, the conjoint culms of many plants supporting the weight of the nest, with the basal, supporting portions of the culms weighed down and leaning outwards—when this island gets flooded by the river rising, the culms are erected and raised just above the highwater level by the force of the current ! Other birds do not nest in this patch of sedges, probably because to land on the nest and take off from it needs the delicate airmastery of egrets (Plate II, 3).

From what has been said, it may be thought that the utilisation of these exceptional nesting sites by the nesting birds at Ranganathittoo is an intelligent adaptation to inevitable circumstances—to the circumstance that while food and other amenities are available here, the nesting trees are limited : it may be also thought that nesting on islands in a swift river also gains them an added measure of security, and that some intelligence is displayed by the birds in this. This is not so. Apart from the risk to their nesting enterprise when the river rises (as much as by 3 feet in a day), even in these island strongholds they are bothered by an undoubtedly intelligent land predator, the bonnet monkey, which swims across, breasting the powerful current, and raids the nests. That the bonnet monkey is not by nature a land predator at the nesting sites of water-birds is true.

Although this is not strictly relevant here, it may be pointed out that not far from this nesting colony, a little farther down the river and barely 250 metres away, there are a number of likely nesting trees along the bank which are never occupied. If intelligence governed, or qualified the nesting of these birds they would certainly exploit these trees. What inhibits them from doing so, apparently, is the purely instinctive preference for nesting in a crowd, in the midst of the established congestion. That there is safety in numbers and in such congestion, especially from avian predators is well known—in passing it may be noted that these predators include, besides birds of prey like eagles and falcons, sneak-thieves like the brahminy kite, the scavenger vulture, and crows. But *if* they colonised those other, unoccupied trees, they would automatically provide their own crowd in this new location—something the birds should know if their nesting was informed by intelligence !

Another point worth noting is this. It may be thought that the detailing of non-arboreal nesting sites at Ranganathittoo and the preference of arboreal sites by the nesting birds elsewhere, where there are close-grown trees, suggests that the latter is the natural condition and the acceptance of non-arboreal sites at Ranganathittoo a contingent, imposed condition. Actually, the reverse is true in the historical sense. In almost all the other water-bird sanctuaries well known today, the nesting trees are not natural and wild but planted by men in groves, whereas at Ranganathittoo these trees are purely natural : Bharatpur, Vedanthangal, Karikili, Dhamal, and Nelappattu are examples of such planted groves. In purely wild locations also (as at Bhitar Kanika and elsewhere, in remote mangrove swamps) these same species of water-birds may be found nesting thickly together in trees, which justifies the mention of their natural preference for trees in this paper, but at present most of the breeding sites are in artificially planted groves in village tanks and in lakes.

Nor is this a recent phenomenon. The *Barringtonia acutangula* grove in the middle of the village tank was already long-established and 'immemorial' in 1798, when the villagers of Vedanthangal presented their petition to Lionel Place, first Collector of the Chingleput District. One of Hume's correspondents refers to a large nesting colony of grey pelicans and the 'pelican ibis' (painted stork) that he noticed in a remote village in the Anantapur district about a century ago, and says the birds were nesting atop tamarinds and were strictly protected by the villagers—the tamarind came to India only some 4 centuries ago and was sedulously planted on the outskirts of villages.

Bharatpur is an instance of an artificial water spread, created for irrigation and military purposes (as General Lake discovered in 1805) and was only subsequently planted, up to its present arboreal richness—incidentally this seems to be the only water-bird sanctuary in India where a sustained attempt has been made to replenish the old, dying nesting trees with others of the same species, carefully planted.* Among the species specially favoured for plantation in village tanks should be mentioned *Acacia nilotica* all over India, *Terminalia arjuna* in the south as also *Barringtonia acutangula* (the former mainly on tank bunds and the latter in the tank bed, in a grove) and, in the north-west, *Mitragyna parvifolia*. *Barringtonia* species are very slow growing and longlived, and survive for centuries, but need to be replenished well in advance of their decadence and death on account of their slow growth.

Nests and Nesting Materials

While water-birds are considered primitive taxonomically, and while it is true that their nests do not exhibit the marvellous instinctive intricacy and refinement of structure of birds like the weavers, some of the warblers or even ioras, the designation of their nests as rough 'stick nests', suggesting a haphazard throwing together of dry twigs, would be incorrect.

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* The idea was originally suggested by Dr. Sálim Ali, Bombay Natural History Society—Eds.

Even in the roughest and simplest of their nests, there is a structural pattern.

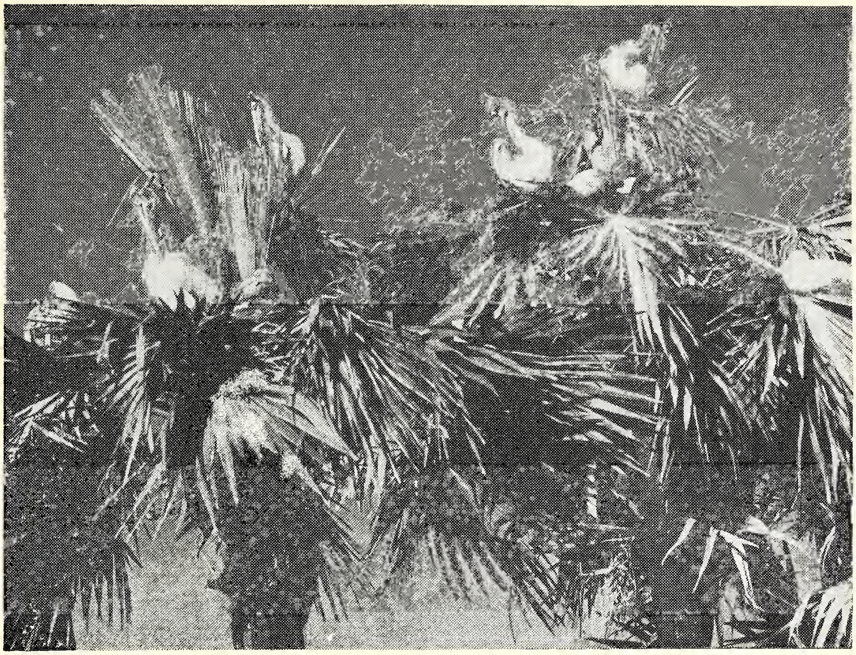
Illustration 4 is a photograph of the main part of the nest of a pair of painted storks, and shows the bulk and strength of the nest in relation to the nesting pair and the two nestlings. The foundation, or basal and outer sides, of a water-bird's nest is always of dry thorny twigs, or dry, much-branched twigs (Plate III, 5) which, when placed on a suitable site, will not only tend to intermesh into a strong foundation and side-walls, but also bind on to the fork of the tree in which it is built, or to the twigs of the treetop on which it is. Obviously, the receptivity or holding power of the site (fork or treetop) on which the nest is built also determines the strength of the attachment of the nest to its site, since water-birds use no binding for this purpose of fibrous materials : a flat-crowned thorny tree, like *Acacia nilotica* offers advantages in this respect which unarmed, smooth-boughed trees like *Mitragyna parvifolia* or *Terminalia arjuna* do not—as against this, the stouter and stronger forks and boughs of these unarmed trees offer a stability to the nest wedged in them that the acacia cannot. Screwpine offers a different kind of peripheral spiny grip to nests built in it, the edges of the fleshy, dorso-ventrally flattened leaves being armed with sharp spines : nests built in sedges and tall grasses also have a firm support below and on the sides—as pointed out already, they are built low, just above the basal parts of the culms, and have a firm if somewhat elastic support from below, having already sunk as low as they can by their weight, and being also partly held up at the sides by the culms.

To some extent, the kind of nesting materials used for building and lining, and replenishing, the nests depends on its location and the kind of nesting site selected. Since purely physical limitations and needs condition this nest site relationship, no attribution of intelligent adaptation by the nesting birds is necessary instinctive skills and responses no doubt govern this relationship.

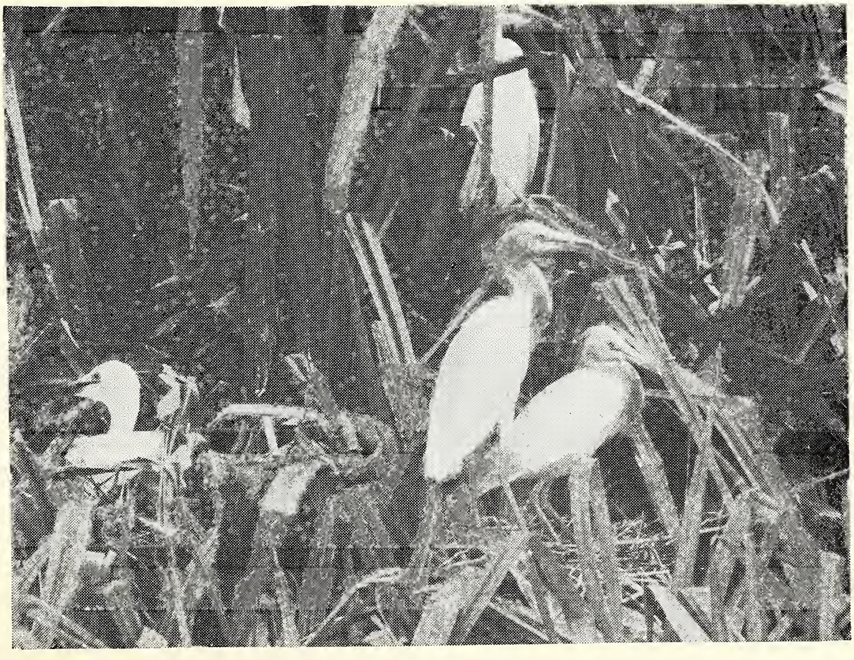
Whatever the site or substratum utilised for the nest, thorny or spinously branched, usually both thorny and much-branched, twigs (dry twigs, not green twigs) are needed for the intermeshed outer shell and foundation of the nest. A variety of thorny twigs are used for this purpose : the most favoured appears to be *Acacia nilotica* twigs which are both strong, somewhat pliant, and thorny, and where this tree is plentiful, as at Bharatpur, the outer shell of the nest is built almost entirely, or quite entirely, of these thorns (Plate II, 4). Naturally the floristics of the surrounds of different nesting sites would determine the kinds of thorny twigs employed in the main.

While water-birds can bring food for their young in their crops from feeding grounds miles away, and actually do so in many places, they have to find the nesting thorns (awkward things to carry, even in the beak) from much nearer, usually in the immediate vicinity of the breeding site. This point may be stressed, as the availability of thorny twigs in a patch of scrub some distance away may not be of much use to the nesting birds : the availability has to be local. While competition for nesting sites is noticeable in the early stages of the breeding enterprise, once the nests are built, apart from threat displays to keep intruders away, there is little competition to be observed at these breeding sites except for nesting material. The thorny twigs may be pulled off the live tree, dry twigs being selected for easy detachment—this is quite usual where acacia thorns are used in the main (Plate III, 5). Egrets and herons may be observed actually fighting for (actively competing for) the displaced dry thorns that have fallen off nests into the water below, for the thorny twigs floating on the water.

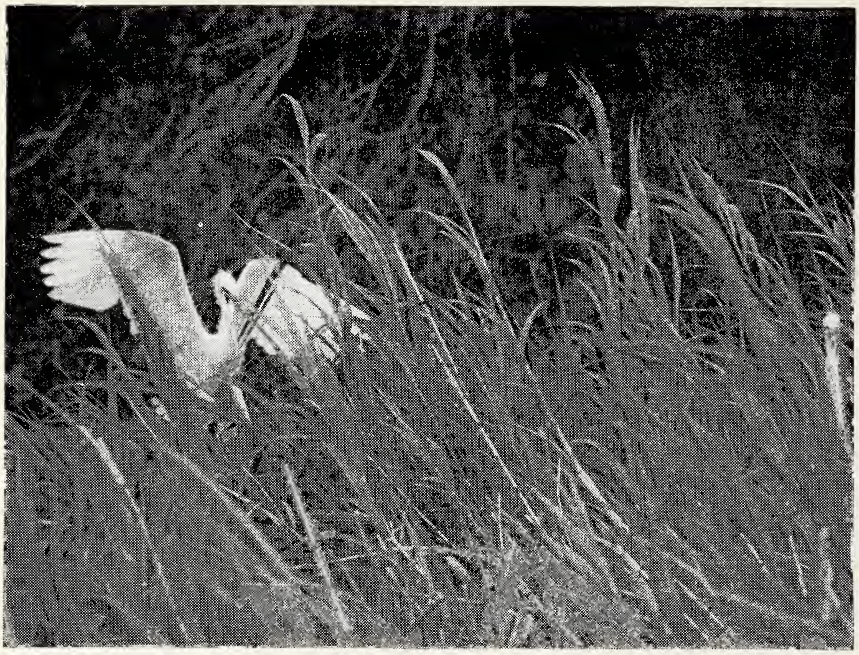
Periodically, as the thorny twigs holding the nest together get detached or weakened, the outer shell of the nest is reinforced with fresh



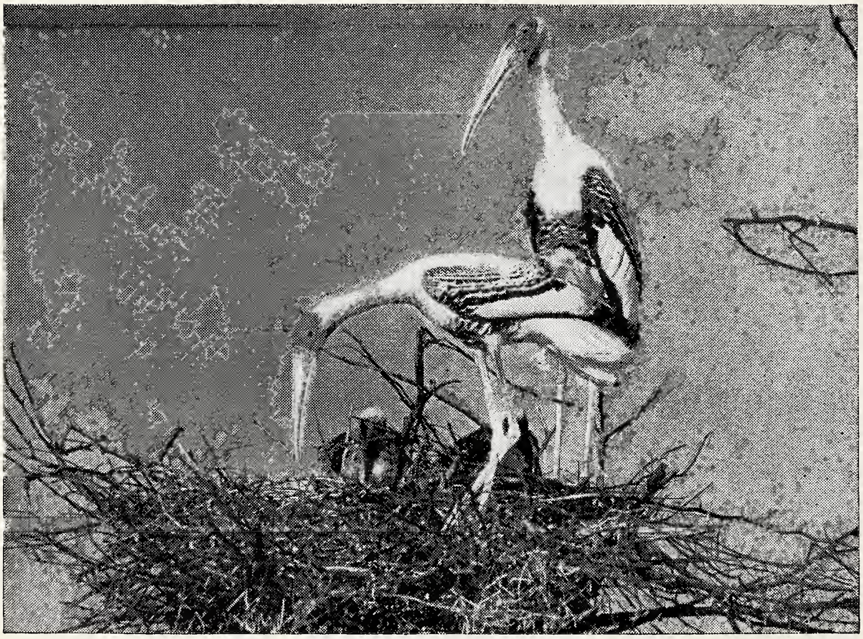
1. Grey pelicans nesting on palmyra tops : Aredu : West Godavari District, Andhra Pradesh.



2. Cattle egrets and median egrets nesting in a screwpine brake, Ranganathittoo Sanctuary, Karnataka.

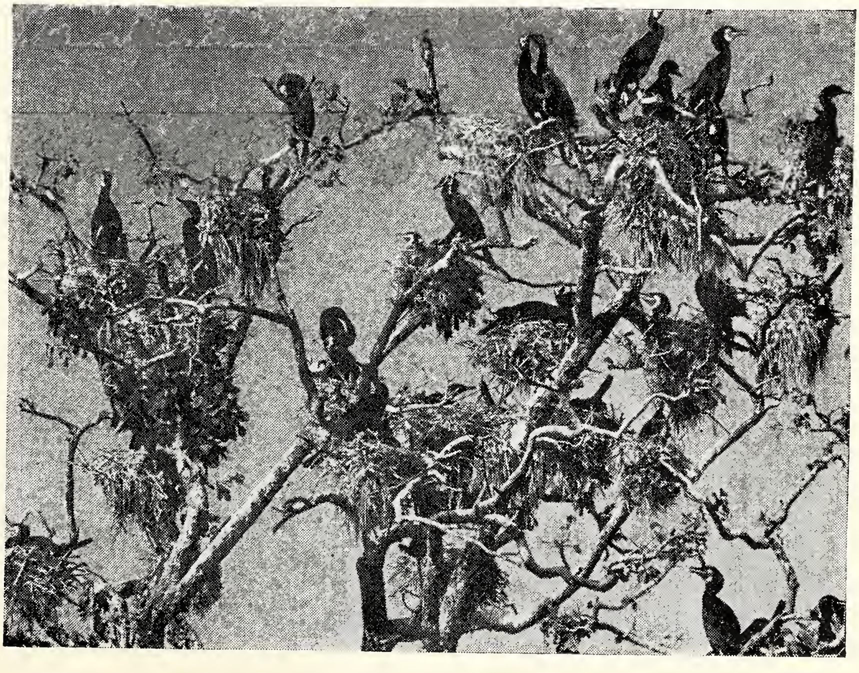


3. A median egret coming in to its nest in the sedges, Ranganathittoo Sanctuary, Karnataka. Note the egret sitting on its nest to the extreme right.

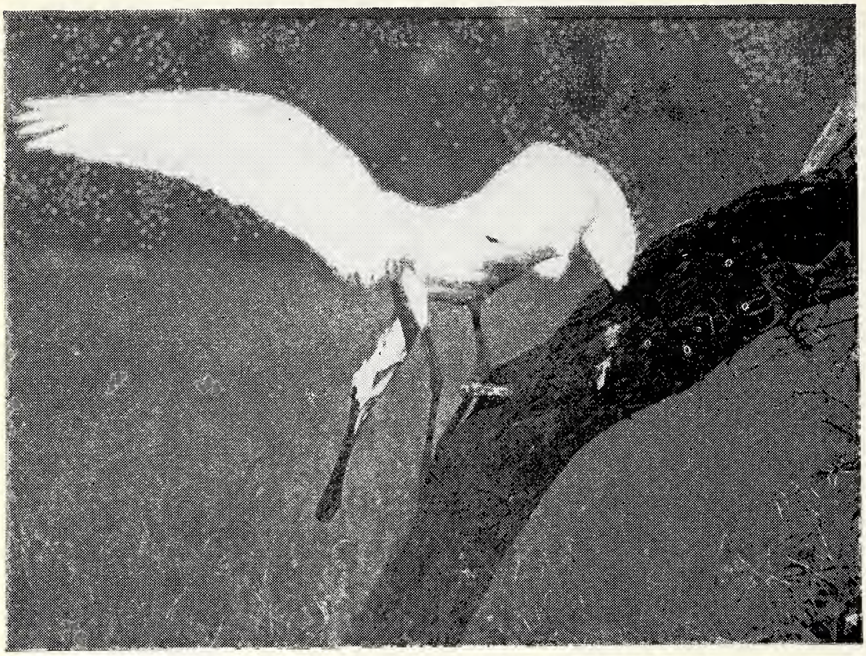


4. A pair of painted storks and their nestlings on their nest: Keoladeo Ghana, Bharatpur, Rajasthan.

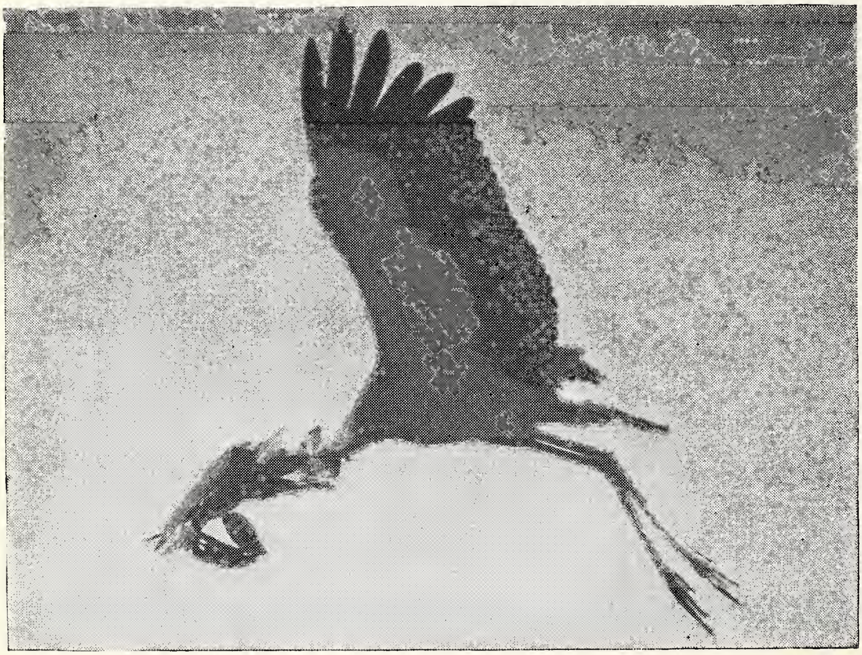
5. Openbill coming in with dry twigs for its nest: Ranganathittoo Sanctuary, Karnataka.



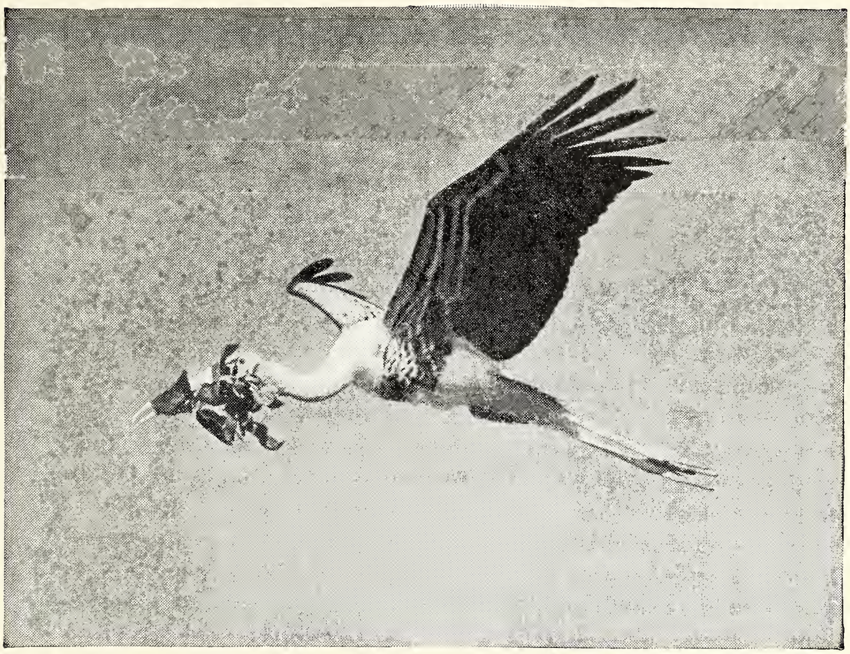
6. The 'large cormorant tree' at Keoladeo Ghana, Bharatpur, Rajasthan. Note the extravagant use of grass to line the nests.



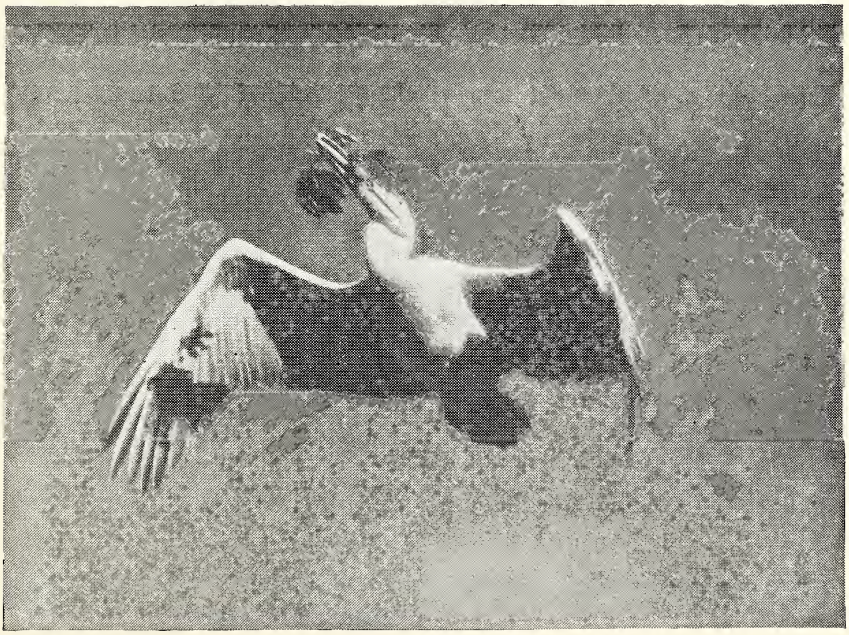
7. Spoonbill slithering down to the grass on the lake bed to pull it out : Keoladeo Ghana, Bharatpur : Rajasthan.



8. Openbill bringing in green leaves for the nest : Ranganathittoo Sanctuary, Karnataka.



9. Painted stork bringing *Mitragyna parvifolia* leaves for its nest : Keoladeo Ghana. Bharatpur, Rajasthan.



10. Grey pelican carrying rain-tree leaves to its nest : Aredu, Andhra Pradesh.

thorny twigs. Once this outer shell is built, it is lined, or filled on the inside, with smooth, unarmed twigs, the top layers consisting even of green twigs with a few leaves attached. This is done even prior to the laying of eggs. This lining material, again, is not brought from far away but from the periphery of the breeding site, or even procured from unoccupied trees in the breeding centre. At Vedanthangal, it was noticed that the deeper nests (openbills, grey herons, large egrets) were thickly lined with the twigs of *Barringtonia acutangula*, which was occasionally detached from the crowns of the nesting trees themselves, but more usually from the unoccupied trees on the periphery of the tank. The birds seem to be less choosy over this lining twigs than over the thorny twigs used for the shell of the nest. In this connection reference may be made to Bharatpur. The large cormorants nesting here build rather heavy nests of stout acacia thorns, securely wedged in the forks and crowns of the nesting trees they favour (either *Acacia nilotica* or *Mitragyna parvifolia*), and well padded with unarmed twigs, but in one particular colony of these birds in a *Mitragyna* tree in the lake behind Shanti Kutir (a large tree almost entirely occupied by large cormorants), the inner lining of twigs has been largely or wholly replaced by dry grass pulled from the lake bed (Plate III, 6). I noticed spoonbills at this sanctuary also pulling drying grass off the lake bed—the bird shown in (Plate IV, 7) took nearly 7 minutes to slither down the sloping trunk of the deadwood it had alighted on to detach a culm of grass and fly away with it.

Once the eggs are hatched, green leaf (in the form of leafy twigs) is brought to the nest and used for lining it, apparently to serve as a cooling superstratum. Many birds at all waterbird breeding centres may be seen bringing in green leaf to the nest at this stage of their breeding enterprise (Plate IV, 8 ; Plate V, 9).

While most birds bring in green leaves (largish leaves) to the nest, some, like spoonbills also bring in thalloid algae and other water plants. The green leaves have also to be found in the vicinity of the breeding site and, in addition, cannot be picked up from the ground or water as dry twigs are frequently picked up, but have to be detached from the plants, almost always along with the green twigs on which they grow. For this reason the mere availability of thorny and twiggy plants (for the earlier stages of the nest construction and subsequent replenishment) alone does not satisfy the requirements of nesting materials of most water-birds—green, leafy plants are also needed in the vicinity of the breeding site.

At the Aredu pelicanry I noticed that while the palmyras provided effective substitutes for the lofty nesting trees in whose crowns grey pelicans nest (when not nesting in trees insulated by water) the search for twigs and green leaves for the nest presented a problem to the birds. They find the vast amounts of fish they need for their breeding enterprise at the Kolleru lake (less than 15 km away) and even in inundated flats nearer home, but have considerable difficulty procuring the twigs and green material they need for the nests, firmly wedged in the crowns among the flattened, strong stalks of the leaves. There were hatchlings in most of the nests when I was there and I found a regular crowd of pelicans at the only mesophytic tree in the neighbourhood, a rain tree (*Pithecalobium saman*), tugging away energetically at twigs from its crown, finding their stance on the thin top boughs precarious during this operation and often toppling over : on detaching a twig with leaves they took it immediately to the nest (Plate V, 10).

It was noticed at Ranganathittoo that egrets, night herons, and even openbills, nesting in and near the tops of the screwpine brakes used much less green leaf for the nests than birds of the very same species nesting in more exposed locations, such as treetops. Elsewhere, too, species nesting inside leafy trees, like night herons, use much less foliage for their nests than those nesting in more open locations. Apparently the green material serves mainly in providing thermal insulation and in cooling.

NECESSARY ENVIRONMENTAL SAFEGUARDS FOR EFFECTIVE CONSERVATION

The main requirements of water-birds breeding gregariously may be listed as follows :

1—Feeding grounds and food. The types of feeding grounds utilised and of the prey favoured or taken in are not detailed here. The feeding grounds may be some distance away from the breeding colony but should be protected from all forms of artificial disturbance (human disturbance). A home water is a great advantage, enabling the grown-up young to feed near their roosts.

2—Nesting trees and other nesting sites : a grove of close-grown trees insulated by their boles being partially submerged (as by their being in a tank bed) would appear to be the most congenial : the trees may also be on islands adequately insulated by water : there may be alternative nesting locations available as in brakes of screwpine (the tree-type screwpine) on islands—these would be specially valuable during the replenishment of the nesting trees periodically. It is imperative to provide new nesting-trees as the old ones decline, the new trees to be well grown by the time the old ones die. This can be effected in more than one way and the physical features of each breeding site would condition the technique best suited to it.

3—It is essential to provide adequate areas of natural thorny scrub also holding mesophytic trees in the vicinity of the breeding site to assure a supply of thorny twigs, unarmed twigs and leafy material. In all water-bird sanctuaries known to me this has not been provided for. It would be interesting to experiment with the provision of detached dry twigs (as of acacia) in this nesting-material area to ascertain if the birds will accept this artificial provision, but in all other ways the area reserved for nesting material must be strictly conserved, be adequate and adequately varied to suit the varied requirements of the nesting birds, and be fully protected. It should be fairly open scrub, to allow free access to the birds without creating any difficulties in their landings and take-off, and feature mesophytic trees at intervals, as also such shrubs.

WINTERING HABITS OF THE BLUE CHAT *ERITHACUS BRUNNEUS* (HODGSON), IN THE NILGIRIS, SOUTHERN INDIA

Mohammad Ali Reza Khan[1]

INTRODUCTION

The Blue Chat *Erithacus brunneus* is a winter visitor in the Nilgiris and in other parts of the Western Ghats (Ripley 1961, Ali and Ripley 1973). During my study of the Black-and-Orange Flycatcher *Muscicapa nigrorufa*, between September 1974 and September 1976, I also had occasion to observe the Blue Chats in all my study areas in Coonoor (1750 m above msl), Kotagiri (1800 m) and Ootacamund (2200 m). Hardly anything is known about it except in a general way (see Ali 1969, Ali and Ripley 1973). In this report I have described the wintering habits of this Himalayan species.

METHODS AND MATERIALS

As the Blue Chats are not shy birds I could easily follow them from close quarters even without the binoculars. One single male Blue Chat was followed over 15 days when it was under direct observation for 5 hours a day. A couple of them was mist-netted and banded with the numbered aluminium rings of the Bombay Natural History Society. An estimate of population was made in the Government Botanical Garden (Ootacamund) and environs (*c* 25 h); Sims' Park and environs (*c* 15 h)., Forest Lodge Shola and environs (*c* 10 h) and Hebron School Shola (*c* 3 h), all within Coonoor municipal limits. The individuals were counted directly. Counting was not difficult as I visited all these plots frequently and regularly and the birds seemed to be parochial. No attempt was made to collect specimens for the purpose of stomach analysis and no insects were collected for identification. A pair of 10 × 50 binoculars was often used.

RESULTS AND DISCUSSION

Arrival and Departure

Like the Grey Wagtail *Motacilla caspica*, the Blue Chat is one of the earliest migrants to arrive and among the last to depart from the Nilgiris. In Coonoor and Ootacamund (Ooty) I noted 15 birds in mid-September. By the middle of October almost every other hedge or bush, be it along residential quarters, in gardens, or in the sholas (Southern Montane Wet Temperate Forests of Champion and Seth 1968) were occupied by an individual. From October to April end the Blue Chat is one of the commonest species. The northward migration possibly starts by April. All 12 birds in 1974-1975 and 15 in 1975-1976 in my study plots at Coonoor and Ooty were noticed to the middle of April. By the first week of May none were seen in any part of the Nilgiris. The birds which were banded in Nov. 1974 were not sighted again nor was there a recovery of the rings. The Blue Chats had arrived singly and possibly departed singly too. There was no sudden influx or disappearance in any particular area.

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Habitat, Status and Population

The Blue Chat occupied all available undergrowth irrespective of the type of cover. The undergrowths of the sholas, eucalyptus plantation, bushes along perennial streams, and amongst tea fields, road-side thickets of *Rubus, Lantana, Solanum, Cestrum aurantiacum* etc., are their favourite haunts. The habitat preference seemed to be almost exclusive. They preferred places which were almost unoccupied by the resident species excepting the Rufousbellied Shortwing *Brachypteryx major* and the Black-and-Orange Flycatcher. The shortwing is a bird of the thickest part of the jungle and is more secretive than the Blue Chat. The flycatcher is not terrestrial like the Blue Chat. Thus the chat did not perceptibly compete with it for the habitat.

The Blue Chat can be considered as one of the commonest species during winter in the upper plateaux of the Nilgiris and other southern Indian hills like the Biligirirangans in Karnataka, the Nelliampathies, High Range and Cardamom Hills in Kerala, the Anaimalais, the Palnis, the High Wavy Mountains, Agastyarmalai and the Ashambu Hills in Tamil Nadu, falling within the Western Ghats, usually above 1000 m. In the Nilgiris I never saw it below 800 m, though I came across it twice around 200 m on my way to Agastyarmalai. It always occurred singly.

The result of population count shows four birds in the Botanical Garden (almost devoid of undergrowth), 6 in Sims' Park, 7 in the Forest Lodge Shola and 3 in the Hebron School Shola. On the average 2.65 hectares supported one Blue Chat. In abundance this species was next to *Phylloscopus* spp. and *Acrocephalus dumetorum* among the migrants, and *Pycnonotus jocosus* and *Hypsipetes* spp., *Zosterops palpebrosa* and *Prinia socialis* among the residents.

Sex Ratio

The peculiar ratio of the sexes is a point of particular interest in this species. Out of 20 birds observed in the study plots only one was female and the rest all males (by plumage). The few birds I trapped turned out to be males too. In two years I came across over one hundred birds in the Nilgiris, excluding those only heard, of which only two were females by plumage. The Blue Chats are sexually dimorphic when adult and the plumages are unmistakable. Although they lived in deep shade it was easy to approach and watch at close quarters. The only likely reason for the sighting of more males is that the sexes do not move together and that the females winter elsewhere. This needs further study.

Parochiality and Territoriality

I do not know if the Blue Chats are parochial in their winter quarters everywhere. But in the Nilgiris each male invariably remained in one particular area throughout the winter months. They had hardly moved out of their preferred shrubbery during the whole period of their stay. Apparently they were also territorial. Two birds were hardly ever found in close proximity. In two cases I saw a male intruding into the territory of another and being chased off by the territory owner. They did not perform elaborate agonistic displays and merely rushed at the intruders with *tuck-tuck* notes and twitching the stumpy tail up and down. The Blue Chats were hostile towards the Black-and-Orange flycatcher when the latter came within one metre or so on the ground. They did not chase when this flycatcher was off the ground. Price (1933) and Lack (1953) have recorded defending of winter territories in American and European Robins, respectively.

Food and Feeding Habits

All food materials were collected by the birds from the ground. I observed them collecting earthworms and large number of caterpillars and larvae in addition to insects settled on the thickish leaf litter.

On the feeding ground the Blue Chats competed for food with the Rufousebellied Shortwing, Blackbird *Turdus merula*, Nilgiri Thrush *Zoothera dauma*, Magpie-Robin *Copsychus saularis*, Tickell's Blue Flycatcher *Muscicapa tickelliae* and the Black-and-Orange flycatcher. Competition for food did not appear to be strong with any of these. The blue chats usually avoided all these species except the last which they always chased.

In November 1974 I was observing a single male Blue Chat in a small plot of some 10 × 3 m, in the Sims' Park, Coonoor. There was a male Black-and-Orange Flycatcher in that bush too. These two were the only occupants of the shrubbery although many others used it as their occasional feeding and resting place. The shrubbery was composed of *Cestrum aurantiacum* and a few *Ipomea*, *Passiflora* and *Callitris*. Here the chat foraged regularly and systematically from one end of the bushy patch to the other. The process was repeated throughout the day except during the siesta mentioned below.

The chats neither turned over dead leaves nor scratched the ground for food as is the usual practice with babblers and the Blackbird. Sometimes they collected food at the same spot for several minutes at a stretch. They preferred the edges of their territory for this activity. In the Botanical Garden they were often seen along the base of the ornamental hedge plants collecting food from the ploughed up soil. Sometimes they hopped out into the open for an insect.

General Habits

Ali and Ripley (1973) have summarized the habits of the Blue Chat. The bird is not shy, and if one remains quiet it can be observed even from a metre distance. In the Botanical Garden they were often seen along main pathways oblivious of the traffic. They spend most of their time on the ground and usually live within a metre or so of it and are partial to sheltered streamlets and drains.

At least thrice a day they take rest, at *c* 0800, at 1100 and *c* 1500 hrs. At the time of rest the birds perch half a metre or so above the ground and preen their feathers thoroughly. This activity is often interrupted by the *tuck-tuck* call-notes and short whistles, and tail twitching. They also produce several low, soft and melancholy notes almost like a soliloquy. The rest period lasts for about five minutes after which the birds descend to the ground and resume foraging. Similar soliloquizing is performed by the Black-and-Orange Flycatcher and the Rufous-bellied Shortwing during the rest period. No published literature mentions it.

The Blue Chats under observation became active at *c* 0615 hrs. Their first activity was a vigorous preening and soliloquizing. They retired at *c* 1830 hrs. spending almost 12 hours of the day in collecting food and in other daily chores. Roosting was always in the same shrubbery and usually at the same spot. I have noticed heavy droppings under such roosts. They prefer the thickest part of a bush for roosting and usually within a metre off the ground. They do not allow the Black-and-Orange Flycatcher to roost near them (Khan 1977). I have not noticed the Blue Chats join other birds in mobbing predators. At the sight of a predator they quickly withdraw inside the bush.

Song and Call-Notes

On arrival in the Nilgiris the birds had a loud *quick-quick-quick* etc., song (Magrath in Ali and Ripley 1973). A few of the early arrivals (3 out of 20 birds observed) retained this song. Towards the end of March and in April, many again developed this song before departing for the breeding quarters.

In winter months the Blue Chats are quite vocal although their voice is feeble and in my estimation they rank next to Blyth's Reed Warbler. Their normal and characteristic call-note is *tuck-tuck* described by earlier authors as an alarm note. This note is sometimes followed by a whistling *twitch-tweech* somewhat similar to *tui* or *twee* of the Black-and-Orange Flycatcher (Khan, loc. cit.). Like the Rufous-bellied Shortwings and the Black-and-Orange Flycatchers, the Blue Chats are more often heard than seen.

The habitat preference, ratio of the sexes, pattern of arrival and departure, and relationship with the resident birds could be good subjects for further study.

ACKNOWLEDGEMENTS

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A CONTRIBUTION TO THE ECOLOGY OF INDIAN PIED MYNA, *STURNUS CONTRA CONTRA* LINNAEUS

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(*With two plates and a text-figure*)

INTRODUCTION

Birds play an important role in relation to agriculture. Many land birds feed on insects including insect pests of agriculture and horticulture. But they also feed on cereal grains, fruits and fishes. Thus the evaluation of their exact role as beneficial or harmful to the farmer becomes all the more important.

Mynas and starlings are generally considered to be friends of the farmer. These birds are known to feed on agricultural pests such as grasshoppers, crickets, beetles, ants, cutworms and caterpillars. Like many other species they too feed on cereal grains and fruits. A study of the food and feeding habits and breeding biology of the Indian Pied Myna *Sturnus contra contra* Linnaeus (Sturnidae) was undertaken to assess the exact role played by the bird in agriculture.

The pied myna is one of the commonest species of birds in northern and eastern India. Local and patchy in distribution, it is found upto *c* 700 m in the foothills.

This species is sociable, predominantly insectivorous, and ground feeding. It is found in noisy squabbling flocks when not paired off for breeding, commonly in association with other mynas. It affects villages and human habitations. Its favourite feeding sites are damp grazing grounds, banks of ponds and tanks, sewage farms and municipal refuse dump.

STUDY AREA

Physiography :

Studies on food and feeding habits and breeding biology of Indian Pied Myna were carried out during the years 1974-76 and early 1977 in and around the city of Dehra Dun, situated at an altitude of 650 m and located in the Doon Valley in the northern part of Uttar Pradesh at 78°2′ E. longitude and 30°20′ N. latitude. The valley is surrounded by the Himalayas on the north-east and by Siwalik hill ranges on south-west and bounded by the rivers Jamuna and Ganga on the north-west and south-east (Fig 1).

The valley is covered by deciduous forests and scrub in the Sub-Himalayas and Siwalik foot-hills. Major part of the valley is cultivated.

The flora around the city of Dehra Dun furnishes a long list of plants including shrubs and timber trees. Prominent among the latter are : Sal *Shorea robusta*, Sheesham *Dalbergia sissoo*, Cheer *Pinus longifolia*, Khyr *Acacia katechu*, Siris *Acacia serissa*, Sain *Dentaptera tomentosa* and Silver Oak *Grevillea robusta*. Among the shrubs *Lantana* sp. and *Zizyphus* spp. are common.

Climate :

The climate of Dehra Dun differs from that of the plains of northern India. The temperature is slightly lower because of its elevation and the forest range of Siwaliks partly blocks off and cools the scorching winds that blow during

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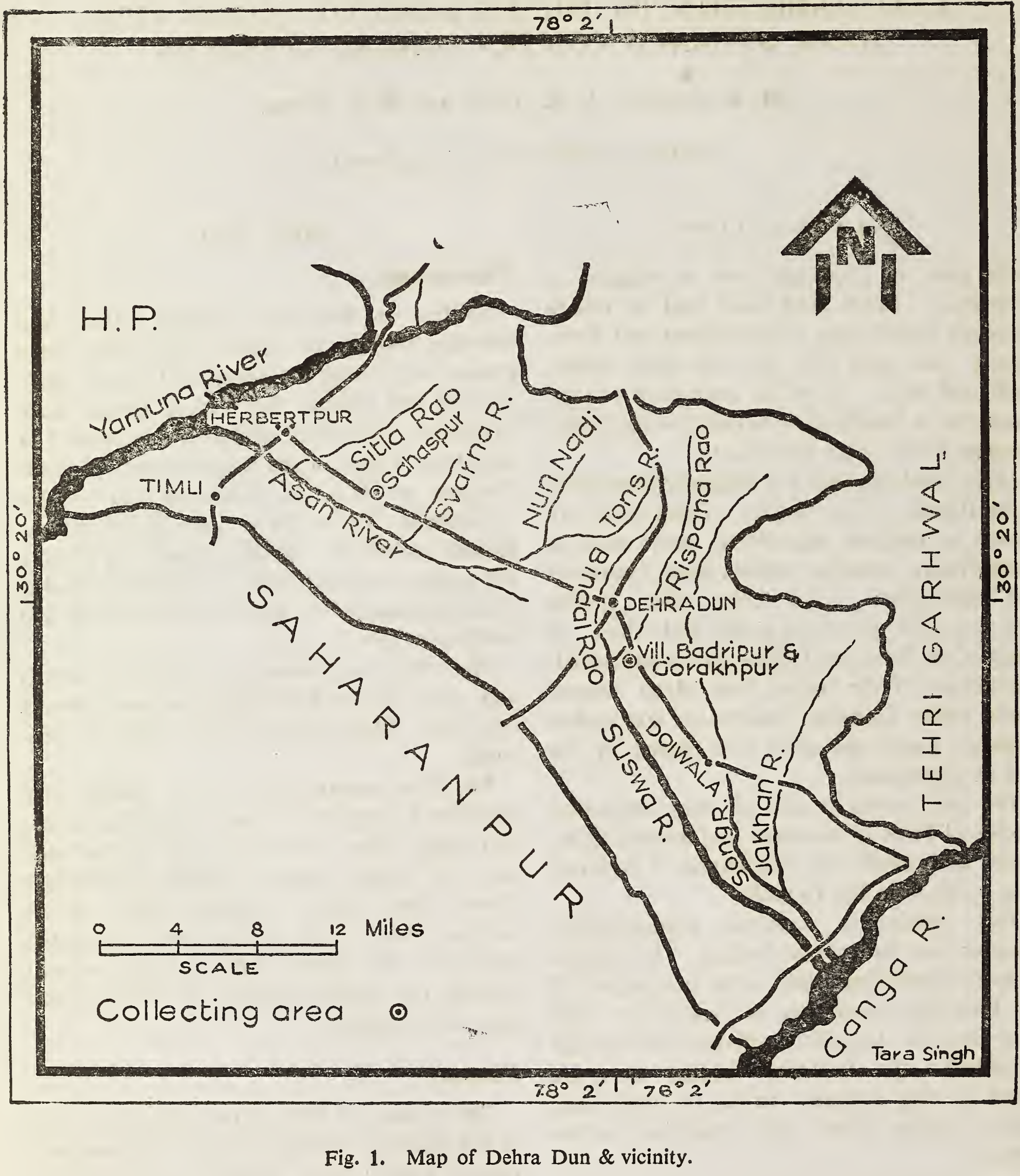
78° 2′
H. P.
N
Yamuna River
HERBERTPUR
TIMLI
Sitla Rao
Sahaspur
Svarna R.
Asan River
Nun Nadi
Tons R.
Rispana Rao
Bindal Rao
DEHRADUN
Vill. Badripur &
Gorakhpur
SAHARANPUR
Suswa R.
DOIWALA
Song R.
Jakhan R.
TEHRI GARHWAL
Ganga R.
30° 20′
30° 20′
0 4 8 12 Miles
SCALE
Collecting area
Tara Singh
78° 2′
76° 2′

Fig. 1. Map of Dehra Dun & vicinity.

the hot weather in the north Indian plains in summer. Being located in the valley, it is protected by Mussoorie hills from cold Himalayan winds during winter. The average of mean minimum annual temperature of this area ranges between 3°C (December) and 22.5°C (July) and the mean maximum between 19.1°C (January) and 30°C (June).

Seasons :

A year at Dehra Dun may be divided climatically into three main seasons.

The cold season begins from November when the average minimum temperature drops to about 6°C and extends to February when the average minimum temperature is 5.7°C, December being the coldest month with the mercury dropping as low as 2.7°C at times.

The hot season may be said to begin from the middle of March when the average maximum temperature shoots upto 26.2°C. The rise in temperature continues, reaching its maximum in mid June when the average maximum temperature rises to 35.2°C. Thus May and June are the hottest months in Dehra Dun. With the onset of rains by June end/early July the temperature starts falling again.

The wet season is ushered in by south-west monsoon by the later half of June and it continues upto September. July and August being the months of heaviest rainfall.

Rainfall :

The south-west monsoon is the chief source of rains in Dehra Dun though some rainfall usually occurs almost throughout the year. The monsoon breaks over Dehra Dun by the later half of June, is at its heaviest during July and August and gradually tapers in September. July has the maximum rainfall sometimes having as much as 729.4 mm of rains. November is a dry month. In winter also (December to February) on an average 43 mm of rainfall occurs in Dehra Dun. The average annual rainfall for the last fifteen years as recorded by the Forest Influences Section of Forest Research Institute and Colleges, Dehra Dun is 2058.5 mm.

Monthly mean rainfall for the years 1974-1976 is given in Table 1.

Humidity :

The city of Dehra Dun being enclosed by Himalayas on one side and Siwalik on the other. It has dense vegetation. The area attracts heavy rains. All this adds to increase the relative humidity which is considerable throughout the year reaching its maximum during summer and winter rains. During winter rains it may reach to a maximum of 97%. April and May are the driest months.

The monthly mean relative humidity for the years 1974-1976 is given in Table 2.

Temperature :

The monthly mean minimum of daily temperature ranges from 2.7°C in December to 23.3°C in July, while the mean of daily maximum ranges from 17.7°C in January to 36.9°C in May. The monthly mean temperature is the lowest in December. It rises steadily thereafter until the maximum is reached in June. The daily range of temperature is least during the months of July and August (about 6-8°C) while in winter season it is generally large (about 13-15°C).

The monthly mean minimum and maximum temperature for the years 1974-76 are tabulated in Tables 3 and 4.

Period of Sunshine :

The monthly mean of hours of bright sunshine ranges from 3.9 hrs to 10.8 hrs. July being the monsoon month has the lowest hours of bright sunshine. (Table 5).

TABLE 1

MONTHLY MEAN RAINFALL (IN MM) FOR THE YEARS 1974-1976

Years	Months											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1974 ..	52.9	20.6	5.4	8.0	40.5	78.4	729.4	452.5	47.5	26.3	0.0	67.8
1975 ..	71.1	67.1	119.2	0.0	21.4	380.1	430.8	487.7	428.2	48.8	0.0	0.0
1976 ..	26.5	72.2	21.5	10.1	39.0	129.2	669.7	556.2	106.1	4.3	0.0	1.6

TABLE 2

MONTHLY MEAN RELATIVE HUMIDITY (IN PER CENT) FOR THE PERIOD 1974-1976

Years	Months											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1974 ..	95	91	85	72	60	73	90	93	90	89	90	92
1975 ..	93	93	88	73	62	74	90	93	93	91	95	96
1976 ..	96	94	90	79	68	74	90	95	94	92	95	97

TABLE 3

MONTHLY MEAN MINIMUM TEMPERATURE (IN °C) FOR THE YEARS 1974-76

Years	Months											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1974 ..	4.4	5.0	10.8	14.9	17.8	21.2	22.5	22.6	19.9	13.9	6.1	4.0
1975 ..	4.6	6.0	9.3	13.3	17.0	20.8	21.7	22.0	20.2	15.2	5.4	2.7
1976 ..	4.2	6.2	8.8	12.5	16.5	20.8	23.3	22.1	20.2	13.1	8.5	3.0

TABLE 4

MONTHLY MEAN MAXIMUM TEMPERATURE (IN °C) FOR THE YEARS 1974-1976

Years	Months											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.
1974 ..	19.8	20.9	27.9	34.3	36.6	35.2	30.6	30.0	30.7	28.8	25.7	19.2
1975 ..	17.7	20.6	25.7	33.3	36.9	33.9	30.0	29.8	28.6	28.7	24.1	21.1
1976 ..	19.7	20.1	25.0	31.4	34.5	33.6	30.7	28.9	29.8	29.0	25.8	21.8

TABLE 5

MONTHLY MEAN OF HOURS OF BRIGHT SUNSHINE PER DAY

Years	Months											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1974 ..	7.4	7.5	8.4	10.1	9.7	8.1	5.3	5.7	8.8	8.7	9.3	5.7
1975 ..	5.6	7.7	8.4	9.9	10.8	7.4	5.5	4.6	5.3	8.9	9.4	8.1
1976 ..	6.0	6.2	7.6	9.1	10.1	8.8	3.9	4.5	7.7	10.0	8.2	8.2

PART I

FOOD AND FEEDING HABITS

INTRODUCTION

Our present day knowledge of food of Indian birds is largely based on the findings of Mason and Maxwell-Lefroy (1912). They analysed the food of 110 species of birds collected at Pusa, Bihar. Their findings added valuable information on the food of birds in India. D'Abreu (1918) studied the food of birds in the Central Provinces. Husain and Bhalla (1937) studied the food of 93 species of birds of Lyallpur. Beresford (1944) and, Simwat and Sidhu (1974, 1975) also added to our knowledge of the subject. All these workers have made a qualitative assessment of food of birds. Mukherjee (1969-76) was perhaps the first in India to make a quantitative assessment of the food of birds.

MATERIAL AND METHOD

Birds were collected, mostly with a 12 bore double barrel shot gun using Nos 6-9 shots, from cultivated fields and scrub around the village of Badripur and Gorakhpur near Defence Colony on Haridwar road and cultivated areas around Sahaspur on Chakrata road.

Most of the specimen were collected between 08.30 hrs and 10.30 hrs during summer and between 09.00 hrs and 11.00 hrs during winter. The specimens thus collected were labelled in the field and brought to the laboratory packed individually in polythene bags. Material which was to be examined after 24 hrs was preserved in 5% formalin. The crops and gizzards were then opened and the contents put in screen sieves, washed with water and then placed on a blotting paper and dried in an oven at 30°C for five minutes. The animal and vegetable matter was broadly separated into phyla and classes and weight and volume was recorded on individual data sheets. An electronic single Pan Balance, accurate to 0.001 gms, was used to weigh the samples. A graduated measuring cylinder true to 0.1 ml was used for measuring the volume.

Examples of animal diet were identified in the laboratories of Zoological Survey of India whereas plant materials were determined by Botanical Survey of India. Some insect larvae were identified at the Forest Research Institute and Colleges. Identification of a few insects were confirmed by British Museum (N. H.), London.

Three methods have been used by various workers to determine the food of birds quantitatively, namely, numerical, gravimetric and volumetric methods.

As the objective of our study was to establish the status of this species as beneficial or harmful to the farmer, we opted for a combination of the known methods.

For analysing the animal diet we used a combination of numerical and volumetric methods. The advantage was, if we were to determine the economic status of any item of animal diet, especially insects, we must know its size to determine the extent of its involvement. A combination of numerical and gravimetric methods was followed for analysing the vegetable diet.

Some workers have suggested the examination of whole digestive track but this method seems to give more importance to foods which are hard enough to resist digestion. We have examined the contents of crops and gizzards only as the food articles retain recognisable shape only upto the gizzard.

OBSERVATIONS

The results of our study suggest that the Pied Myna does not go for any specialised diet but feeds upon a variety of food which is seasonally abundant and hence easy to obtain. A year round record of the food taken by the bird during the study period is presented in Table 6.

TABLE 6

SEASONAL FOOD PREFERENCE

Month	Food
January	Caterpillars (unidentified), grubs (unidentified), ants (*Pheidole* sp.), wheat ((*Triticum aestivum* L.), Molluscs (*Kaliella* sp., *Digoniostoma* sp.), beetles (*Oxytelus* sp. *Rhysodes* sp.), termites (*Odontotermes* sp.).
February	Bugs (*Eusarcocoris* sp.), grasshopper fragments, caterpillars, termites (*Odontotermes* sp.), molluscs [*Kaliella* sp., *Indoplanorbis* sp., *Digoniostoma pulchella* (Bensen)], beetles (*Tanymecus* sp., *Drasterius* sp., *Rhysodes* sp.), ticks [*Boophilus microplus* (Canestrini)].
March	Caterpillars (unidentified), beetles (*Oxytelus* sp., *Rhysodes* sp.), molluscs (*Indoplanorbis* sp., *Macrochlamys* sp.), crickets (*Gryllus* sp.).
April	Beetles (*Rhysodes* sp., *Oxytelus* sp., *Coccinella* sp., *Anadastus* sp.), bugs (*Cydnus indicus* West.), ants (*Pheidole* sp.), grubs (Unidentified), molluscs (*Macrochlamys* sp.).
May	Termites (*Odontotermes* sp.), gastropods (*Opeas gracilis* Hutton), caterpillars (unidentified), grubs (unidentified), beetles (*Coccinella* sp. *Rhysodes* sp.), Mole Crickets (*Gryllotalpa* sp.)
June	Ants (*Aphaenogaster* sp.), grasshoppers (*Chrotogonus* sp., *Acrydium* sp.), grubs (unidentified), Cockroaches (*Periplanata* sp.), bugs (*Aeschrocoris* sp.), flower parts of silver oak (*Grevillea robusta* Cam.), beetles (*Scleron* sp.).
July	Berries of Banyan and Peepal (*Ficus benghalensis* L. & *Ficus religiosa* L.), wild seeds (unidentified), seeds of Jamun [*Syzygium cumini* (L.)], ants (*Pheidole* sp.), beetles (*Bembidion* sp.).
August	Earthworms [*Eutyphoeus waltoni* (Michaelson), *Eutyphoeus orientalis* (Beddard)], frogs [*Bufo melanostictus* Schneider, *Microhyla ornata* (Dumeril & Bibron)], Beetles (*Coccinella* sp., *Lyprops* sp., *Crioceris* sp.), earwigs (Partially digested), grubs (unidentified).
September	Earthworms [*Eutyphoeus orientalis* (Beddard)], molluscs (*Macrochlamys* sp.), beetles [*Anadastus bifasciatus* (Mots.), *Anthracophora crucifera* Oliv., *Syncalypta curimoides* Champ., *Crioceris* sp.)], grubs.
October	Lantana berries (*Lantana camara* L.), bees and wasps (*Apis dorsata* Fabr., *Vespa basalis* Smith) termites (*Odontotermes* sp.), flies (*Musca domestica* Linn.).
November	Wheat (*Triticum aestivum* L.), Lantana berries, termites, ants (*Dorylus orientalis* Westwood), beetles (*Aphodius* sp., *Onthophagus* sp.).
December	Grubs, flies (*Musca domestica* Linn., *Drosophilia* sp.), wheat, ants and beetles (*Aphodius* sp.).

A volumetric and gravimetric analysis of food found in the crops is given in Table 7—A & B.

TABLE 7-A

VEGETABLE DIET

Items of diet	No.	Wt. (gm)	% Wt.	Remarks
Family : MALVACEAE				
Hibiscus esculentes	1	1.50	37	
Family : MYRTACEAE				
Syzygium cumini (L.)	2	1.10	34	Endocarp only
Family : SOLANACEAE				
Solanum tuberosum L.	1	91 mgm	50	
Family : VERBANACEAE				
Lantana camara L.	21	2.40	100	Berries
Family : PROTEACEAE				
Grevillea robusta Cam.	6	21 mgm	10	Flower parts
Family : MORACEAE				
Ficus benghalensis L.	3	17 mgm	8	Seeds
Ficus religiosa L.	2	23 mgm	13	Seeds
Family : GRAMINEAE				
Triticum aestivum L.	6	83 mgm	28	Germinating seeds
MISCELLANEOUS				
Gramineae seeds	3			Unidentified
Unidentified seeds	3	1.80	100	-do-
Misc. vegetable matter				-do-

TABLE 7-B

ANIMAL DIET

Items of diet	No.	Vol. (ml.)	% Vol.	Remarks
Phylum ; Chordata				
Class : Amphibia				
Order : Salientia				
Family : MICROHYLIDAE				
Microhyla ornata (Dumeril & Bibron) ..	1	0.6 ml	30	Adults
Family : BUFONIDAE				
Bufo melanostictus Schneider ..	1	0.7 ml	28	-do-
Phylum ; Annelida				
Class: Oligochaeta				
Order : Terricolae				
Family : MEGASCOLECIDAE				
Eutyphoeus waltoni (Michaelson) ..	2	1.9	86	Mostly in parts
E. orientalis (Beddard)	5	0.8 ml	73	-do-

TABLE 7-B—(*Contd.*)

ANIMAL DIET

Items of diet	No.	Vol. (ml)	% Vol.	Remarks
Phylum ; Mollusca				
Class : Gastropoda				
Order : Stylommatophora				
Family : ARIOPHANTIDAE				
Macrochlamys sp.	6	0.2 ml	12	Complete and broken shells
Kaliella sp.	5	0.1 ml	8	Complete shells
Family : SUBULINIDAE				
Opeas gracilis Hutton	3			Complete shells
Order : Megagastropoda				
Family : ANINICOLIDAE				
Digoniostoma sp.	4			Complete & partially broken shells
D. pulchella	9	0.4 ml	57	-do-
Order : Basommatophora				
Family : LYMNAEIDAE				
Indoplanorbis exustus (Deshayes) ..	5	0.2 ml	25	Complete & broken shells
Misc. Mollusca (Fragments of shells) ..				Not identifiable
Phylum ; Arthropoda				
Class : Insecta				
Order : Orthoptera				
Family : TETRIGIDAE				
Acrydium sp.	3	0.2 ml	8	Partially digested
Family : GRYLLIDAE				
Gryllus sp.	2	0.4 ml	27	Destroys clothes, paper, fruit etc.
Family : GRYLLOTALPIDAE				
Gryllotalpa sp.	5	1.2	59	Partially digested. Damages roots of crops.
Family : ACRIDIDAE				
Chrotogonus sp.	3	0.9 ml	29	Partiallydigested. Pest of paddy, jowar etc.
Misc. Grasshoppers (fragments) ..				Not identifiable.
Order : Dermaptera				
Family : LABIDURIDAE	5	0.4 ml	21	Parts of earwigs.
Order : Dictyoptera				
Family : BLATTIDAE				
Periplaneta sp.	6	0.7 ml	60	Parts of cockroaches. Pest.
Order : Isoptera				
Family : TERMITIDAE				
Odontotermes sp.	8	0.1 ml	15	Partially digested.

Items of diet	No.	Vol. (ml)	% Vol.	Remarks
Order : Hemiptera				
Family : PENTATOMIDAE				
Aeschrocoris sp.	3	0.2 ml	5	
Eusarcocoris ventralis West.	2	0.9 ml	30	
Cydnus indicus West.	4	0.2 ml	16	
Family : MEMBRACIDAE				
Oxyrhachis taranda (Fabr.)	2	0.1 ml	9	Pest on citrus and mango trees.
Order : Diptera				
Family : MUSCIDAE				
Musca domestica Linn.	3	0.2 ml	7	Carriers of germs of various diseases.
Family : DROSOPHILIDAE				
Drosophila sp.	2	0.2 ml	6	
Family : EPHYDRIDAE	1			Partially digested identified upto family level.
Misc. Flies (Fragments)				Not identifiable.
Order : Hymenoptera				
Family : APIDAE				
Apis dorsata Fabricius	2	0.3 ml	23	Helps in pollination.
Family : VESPIDAE				
Vespa basalis Smith	2	0.5 ml	24	
Family : FORMICIDAE				
Pheidole sp.	7	0.3 ml	100	Pest of wheat, paddy etc.
Aphaenogaster baccari Emery	5			
Dorylus orientalis Westwood	3			Pest of plants and trees.
Family : CHALCIDAE	1			Partially digested, identified upto family level.
Misc. Ants, Bees, Wasps (Fragments)				Not identifiable.
Order : Odonata				
Family : LIBELLULIDAE				
Tramea verginia (Rambur)	2	0.5 ml	16	Naiads.
Order : Coleoptera				
Family : LANGURIIDAE				
Anadastus bifasciatus (Mots.)	7	0.2 ml	13	
Family : RHYSODIDAE				
Rhysodes boysi Arrow	11	0.6 ml	21	
Family : LIMNICHIDAE				
Platypelochares latimargo Champ.	3	0.3 ml	11	
Family : BYRRHIDAE				
Syncatypta curimoides Champ.	6	0.4 ml	17	
Family : COCCINELIDAE				
Coccinela sp.	6	0.2 ml	23	Pest of leaves of family Cucurbitaceae.

TABLE 7-B—(*Contd.*)

ANIMAL DIET

Items of diet	No.	Vol. (ml)	% Vol.	Remarks
Family : CURCULIONIDAE				
Tanymecus sp.	5	0.5 ml	17	Adults injurious to leaves of low growing plants. Larvae are root feeders.
Family : CARABIDAE				
Bembidion sp.	3	0.4 ml	12	Pest of corn and strawberries.
Family : TENEBRIONIDAE				
Anthracophora crucifera Oliv.	2	0.4 ml	29	
Scleron sp.	2	0.1 ml	14	Pest of tobacco.
Gonocephalum sp.	4	0.3 ml	23	Injurious to seeds of *Shorea robusta* and damages roots of sugarcane, coffee,tobacco etc.
Lyprops sp.	5	0.4 ml	19	
Opatroides sp.	3	0.2 ml	17	
Family : STAPHYLINIDAE				
Oxytelus (*Anotylus*) *andrewesi* Cameron	7	0.3 ml	25	Carnivorous. Reported devouring ants.
Philonthus sp.	2	0.2 ml	18	
Family : SCARABEIDAE				
Aphodius sp.	6	0.2 ml	45	
Onthophagus sp.	5	0.4 ml	67	
Family : ELATERIDAE				
Drasterius sp.	9	0.1 ml	21	Pest of potato.
Family : CHRYSOMELIDAE				
Crioceris sp.	9	0.2 ml	17	Partially digested.
Order : Lepidoptera				
Caterpillars	18	1	60	Not identified.
MISCELLANEOUS				
Grubs	16	0.9 ml	69	Not identifiable.
Insect fragments				-do-
Class : Arachnida				
Order : Acarina				
Family : IXODIDAE				
Boophilus microplus (Canestrini)	3			Ectoparasite on cattle and causes the disease Anaplasmosis.
Hyalomma anatolicum Koch.	2			-do-
Order : Araneida				
Spider	1			Not identifiable.

No.	Number of birds which had taken the item.
Wt.	Maximum wt. (in gms) of item of diet found in any single specimen.
Vol.	Maximum volume (in ml) of item of diet found in any single specimen.
%Wt :	Maximum percentage of food item by wt. found in any single specimen.
%Vol :	Maximum percentage of food item by vol. found in any single specimen.

CONCLUSION

Judging from an analysis of the gut contents we find that these birds mostly feed on insects, lantana berries, molluscs, earthworms and wild seeds. Only a few birds have taken seeds of wheat during the sowing season. Out of 137 birds collected, only six have taken wheat. During the harvesting season none of the specimens had taken wheat or any other grain. This apparently suggests that Pied Myna does not prefer wheat but during sowing season, while taking insects from fields, some wheat seeds are also taken. On the other hand these birds took a heavy toll of insects some of which are injurious to agriculture. A few birds have consumed ticks which are ectoparasites on mammals and cause diseases such as anaplasmosis. Earthworms bring organic matter above the surface of earth and make the soil more fertile. During the rainy season this bird may be said to cause some harm to farmers by feeding on earthworms. However, we can safely conclude that the Indian Pied Myna is much more beneficial than harmful to agriculture.

PART II

BREEDING BIOLOGY

INTRODUCTION

Our present day knowledge of the breeding biology of the Indian Pied Myna remains restricted mainly to the topics dealt with by Jerdon (1862-64), Hume (1873, 1889-1890) and Baker (1933). Very little has been added to it in spite of the fact that a number of workers (Cripps 1878 ; Ried 1881, 1887 ; Barnes 1890, Inglis 1901, 1910 ; Osmaston 1913 ; Whistler 1919 ; Field 1922 ; Gill 1922 ; Briggs 1934 ; Ara 1954 ; to cite a few) have written on one or the other aspect of the breeding habits of this bird.

MATERIAL AND METHOD

Most of the observations for this study were made in the field through 6 × 30 prismatic field binoculars. Observations were started before the flocks disintegrated into pairs.

Before and during the nest building stage the sexes, wherever necessary, were determined by actual examination of the gonads after killing the bird. After the construction of the nest one (and in some cases both) of the occupants was captured with mist nets and ringed with coloured plastic rings for visual recognition.

The process of nest construction was watched from a safe distance from behind a stout tree/bush or from within a parked vehicle. The material used for nest construction and dimensions of the nest were recorded from a few nests brought to the laboratory for the purpose.

Soon after the start of nest construction regular daily examination of the nest was made by climbing upto it. Occasionally light bamboo ladders (6 to 8 metres) were used for the purpose. Nests situated on very thin branches were examined with the help of small boys who would communicate or lower the contents in a small tin container for taking notes, measurements and weights. The contents were then replaced intact.

During the laying and hatching periods a number of selected nests were observed daily between 0530-0730 hrs, 0930-1230 hrs and 1630 to 1830 hrs for certain specific observations. Extra but irregular visits were made at night, dawn and dusk.

Eggs for incubational studies were marked with indelible India ink. For recording description and measurements, eggs from certain deserted nests and nests that are difficult to approach for regular observations, were brought to the laboratory. A pair of vernier callipers was used to take measurements in milimetres. An electronic single-pan balance true to 0.001 g was used to record the weight of eggs. The colour of the shell was determined by comparison with ' Methuen handbook of colour '. Successive eggs of a selected number of clutches were measured and weighed in the field.

In a few selected nests the freshly hatched nestlings were banded with coloured plastic bands for studying growth rate and behaviour patterns. Single-pan electronic balance was used for taking weights of the nestlings. Grown up nestlings were put in cloth bags for weighing.

For certain specific studies like growth of feathers etc. some nestlings were brought to the laboratory. Such nestlings were killed to determine the type of food on which they were being fed.

All the nest life studies were made visually by climbing upto the nest or through a pair of 6 × 30 prismatic binoculars from a distance.

The photographs of nests, eggs, nestlings etc, were taken with an Asahi Pentax Camera with a normal 50 mm/F 1.2 lens and a 500 m/F 8 lens.

The map of the study area was obtained from Survey of India, Dehra Dun and data on the weather conditions, from Forest Research Institute and Colleges, Dehra Dun.

BREEDING SEASON

The Indian Pied Myna does not breed round the year. At Dehra Dun it was observed to have a single breeding season of about six months from late February to end of August. In the years of prolonged winter rains the commencement of breeding season may be delayed upto March or even April. In 1975 when rainfall in 2nd half of February was normal the breeding activity i.e. pair formation etc. started normally, i.e. by February end. But on account of sudden increase of winter rains in March (119.2 mm) further progress in breeding activity i.e. nest construction etc. was arrested till the rains slowed down by the end of March. In 1976, on the other hand, the rainfall in the later half or February was much more. As a result the breeding activity i.e. pair formation etc. did not start till the end of March. The breeding activity however, lasted till end of August during both the years 1975 and 1976. Apparently the rainfall does interfere with breeding. In the year 1977 when the rainfall was much more than normal in July, a second brood was not raised although some nest repairing activity was noticed. The extension of the winter rains also retards the commencement of breeding activity in this species. It will, however, be not wise to attribute the delay in the commencement of breeding to any one climatological factor alone. For a detailed discussion on this topic please see Lamba (1977 : 265-266).

Maximum number of nests under construction were observed from March end to early May. Most nests with eggs were met with during April-May and most nests with nestlings were noticed from April end to early June. Some of the early breeders go in for a second brood also. Largest number of second clutches was found during later half of June to later half of July. The nestling from these second broods left the nests by end of August.

Pair formation :

With the commencement of breeding season the large flocks usually seen feeding and roosting in winter, start thinning out. Partners are sought out and courted. The factors involved in the selection of a partner were not ascertained. Pairs once formed remained together for the total duration of the breeding season. In three out of four cases where one of the partners was shot or died when the nest was active another partner was acquired. Once when a male was eliminated after the 1st brood had been successfully raised the female acquired another male and raised a second brood in the same nest. In another case where the female was eliminated after the 1st brood the male deserted the nest and left the area.

Mating :

Copulation takes place either on the ground or in the branches of trees.

Courtship includes feeding together. During courtship display the male puffs up its feathers and bobs its head up and down a couple of times. Copulation may or may not take place immediately after a spell of courtship display. The frequency of copulation is the highest, four times in 6 hours in one instance, when the egg chamber is being constructed. The frequency of copulation decreases as the clutch is being laid and ceases completely after the female starts incubating during the day time. The second peak of copulation activity is reached when the nest is being repaired and reshaped for raising the second brood.

TERRITORY

The male occupies his territory early in the breeding season. The territory seems to be announced by mere presence of the male as no distinctive song or display was noticed. The territory is defended by the owner (male) against all males of the species. All females are welcome till the pair formation takes place. After the pair formation the territory is defended by both the partners against all others of the species who may attempt construction of nest in the same nesting tree. A straggler or an occasional visitor may not be pounced upon. Occasionally, if the tree is very large with spreading branches, another pair or two may be tolerated to build in the same tree. The occurrence of half a dozen nests in a single tree has been recorded by Baker (1933).

Distances between various nests were measured in a guava and mango garden of about 4000 sq. metres. Fourteen nests were found placed at distances varying from 14 to 100 metres from each other.

The Pied Myna defends its territory by threat display and actual combat. The threat display consists of puffing up of the body feathers, especially of the neck region and emitting loud calls with beak open and the neck extended. Normally the threat display is sufficient to frighten the intruders into retreat. If this fails an attack is launched by running or flying up to the intruder. The beak is used as an organ of offence. A number of sparring bouts may occur. The weaker of the two may lie flat on the back and try to use the claws also for defence.

When threatened by a common enemy like a raptor or a snake, some sort of community defence comes into play. In such an event some or all of the neighbouring pairs and even visitors may join hands in response to loud warning calls given out by the bird first to spot the danger. When faced with a large raptor who refuses to be frightened by the noise or ineffective attacks, the birds calm down after a number of attempts and occupy the neighbouring trees only to launch another attack as soon as the raptor leaves its perch.

NEST CONSTRUCTION

Site :

Apparently the nest site is selected by mutual consent, after the pair formation, inside the territory already occupied by the male. The original site may often be given up in preference to another probably more suitable one. This may happen even after the commencement of nest construction.

Generally thin vertical forks in large trees like, mango, banyan, peepal, kathal, guava and sheesham are preferred to place the nests in, at about 5-15 metres high above the ground. Occasionally cross-bars on telegraph poles may be used for the purpose, especially in areas where large trees are wanting.

The birds may take their own time in making the final selection of the nesting site. As many as 10 to 15 days may elapse after the pair formation before undertaking the actual construction of the nest.

Nesting material :

Thin and pliable twigs, stems of small plants, grass stems, stems of creepers and twiners, strings, rags, pieces of paper, discarded cellophane wrappers, polythene bags and similar sundry materials are collected from under the trees, hedges, waste land, garbage cans etc. from the territory and adjoining human habitat, for the construction of the outer dome.

The inside of the dome or the egg chamber is lined with similar but softer materials. Occasionally human or horse hair may also be included in the lining of the egg chamber.

Both sexes gather materials for and take part in the construction of the nest. The female puts in more effort than the male who generally helps in the collection of the material leaving most of the construction work to the female. The female keeps to the vicinity of the nest even when searching for nesting material. When the nest is well under way the female's material hunting trips are greatly reduced. She keeps on working in the nest while male keeps her supplied with requisite material. Once the nest construction starts the nest is never left unguarded. One of the mates is always at hand to defend and protect it from intruders and pairs of the adjoining territories who are not beyond pinching the nesting material from deserted or unguarded nests.

The maximum nest construction activity was observed between 06.00 hrs and 08.00 hrs. It slows down considerably during the day. Towards the evening there is another spurt of nest building activity reaching a second peak during 1600 to 1800 hrs. In the nests started late in the breeding season the frequency of material gathering trips and speed of construction is much more than those started earlier in the season. In some of these cases the material gathering and nest construction may continue throughout the day with short periods of rest and feeding.

During a spell of normal construction activity as many as 38 material gathering trips an hour in the morning and 21 in the evening by both birds, were clocked.

On the approach of a raptor or in the event of a possible threat to the nest even from the observer, the bird outside the nest, usually the male, gives out an alarm call which makes the bird working inside to leave the nest and take refuge in the branches nearby. Alarm calls from a neighbouring male do not elicit such a response.

TIME REQUIRED FOR THE COMPLETION OF THE NEST

Normally it takes about 11 to 22 days for a pair to complete the nest (Table 8). The birds that start building early in the breeding season usually take longer than the ones that start late. In two cases when the construction was started as late as the end of June it took the birds 7 days in one and 8 days in another case to finish the nest.

The nest :

The finished nest is a rough, round or more often elongate, dome approximately 60-80 cm wide and approximately 35 to 50 cm high with a circular side opening 6-8 cm in diameter

TABLE 8

TIME REQUIRED FOR COMPLETION OF THE NEST

Nest No.	Construction started on	Completed on	Time in days
1975			
1	16.4.75	8.5.75	22
2	22.4.75	14.5.75	22
6	17.4.75	9.5.75	22
9/A	20.4.75	8.5.75	18
12	9.4.75	30.4.75	21
13	24.4.75	13.5.75	19
15	28.4.75	13.5.75	15
16	8.5.75	19.5.75	11
17	12.4.75	3.5.75	21
1976			
2	26.4.76	18.5.76	22
3	18.4.76	6.5.76	18
4	20.4.76	6.5.76	16
5	30.4.76	19.5.76	20
7	1.5.76	19.5.76	19
8	3.5.76	21.5.76	18
9	3.5.76	23.5.76	20
10	4.5.76	15.5.76	11
12	13.5.76	26.5.76	13
13	28.5.76	9.6.76	12

(Plate I, Fig. 1). The opening usually faces the fork (Plate I, Fig. 2).

Occasionally a nest may be deserted while still under construction, or even after completion due to lack of security. A nest is rarely deserted after a full clutch has been laid, except when all the eggs are removed. The material from the deserted nest is often utilised in the construction of the new nest.

After the first brood has been successfully raised, the same nest may be used, after slight repairs, for a second brood.

The time lag between the completion of nest and laying of the 1st egg could not be ascertained beyond doubt because of the dome like structure of the nest with narrow opening makes visual observation rather difficult. It was generally observed that after the construction activity ceased or almost stopped the 1st egg was not laid immediately. Usually it was laid 1-3 days after the work ceased on the nest (Table 9). But in some nests the lining of the egg chamber continued even after the 1st egg had been laid. In a few cases the full clutch was laid in an open nest and the dome was constructed later. In three cases (out of some 170 nests studied) the eggs were laid and hatched in an open nest without any attempt at construction of the dome.

CLUTCH

Laying pattern :

Generally four to five and occasionally six eggs are laid at regular intervals of twenty-four hours (Table 10).

Eggs were laid in the early forenoon in 81.6 % of the nests. In 16.1% of the nests

TABLE 9

TIME LAPSE BETWEEN COMPLETION OF THE NEST AND LAYING OF THE 1ST EGG

Nest No.	Nest completed on	1st egg laid on	Time lapse (in days)
1975			
1	6.5.75	9.5.75	3
2	14.5.75	16.5.75	2
6	9.5.75	10.5.75	1
9/1	8.5.75	9.5.75	1
13	13.5.75	15.5.75	2
15	13.5.75	15.5.75	2
16	19.5.75	20.5.75	1
18	24.5.75	25.5.75	1
2/A	24.5.75	25.5.75	1
1976			
2	18.5.76	19.5.76	1
3	6.5.76	8.5.76	2
4	6.5.76	7.5.76	1
5	19.5.76	20.5.76	1
7	19.5.76	21.5.76	2
8	21.5.76	22.5.76	1
9	23.5.76	24.5.76	1
10	15.5.76	17.5.76	2
12	26.5.76	27.5.76	1
13	9.6.76	10.6.76	1

TABLE 10

LAYING PATTERN

Nest No.	First egg laid on	Second egg laid on	Third egg laid on	Fourth egg laid on	Fifth egg laid on	Sixth egg laid on
2A/75	25.5.75	26.5.75	27.5.75	28.5.75	—	—
6/75	10.5.75	11.5.75	12.5.75	13.5.75	14.5.75	—
9/1/75	9.5.75	10.5.75	11.5.75	12.5.75	13.5.75	—
9/2/75	1.7.75	2.7.75	3.7.75	4.7.75	—	—
13/75	15.5.75	16.5.75	17.5.75	18.5.75	—	—
16/75	20.5.75	21.5.75	22.5.75	23.5.75	24.5.75	—
17/75	4.5.75	5.5.75	6.5.75	7.5.75	8.5.75	9.5.75
18/75	25.5.75	26.5.75	27.5.75	28.5.75	29.5.75	—
2/76	19.5.76	20.5.76	21.5.76	22.5.76	—	—
3/76	8.5.76	9.5.76	10.5.76	11.5.76	12.5.76	13.5.76
4/76	7.5.76	8.5.76	9.5.76	10.5.76	11.5.76	12.5.76
5/76	20.5.76	21.5.76	22.5.76	23.5.76	—	—
7/76	21.5.76	22.5.76	23.5.76	24.5.76	25.5.76	—
8/76	22.5.76	23.5.76	24.5.76	25.5.76	—	—
9/76	24.5.76	25.5.76	26.5.76	27.5.76	—	—
10/76	17.5.76	18.5.76	19.5.76	20.5.76	21.5.76	—
12/76	27.5.76	28.5.76	29.5.76	30.5.76	—	—
13/76	10.6.76	11.6.76	12.6.76	13.6.76	—	—

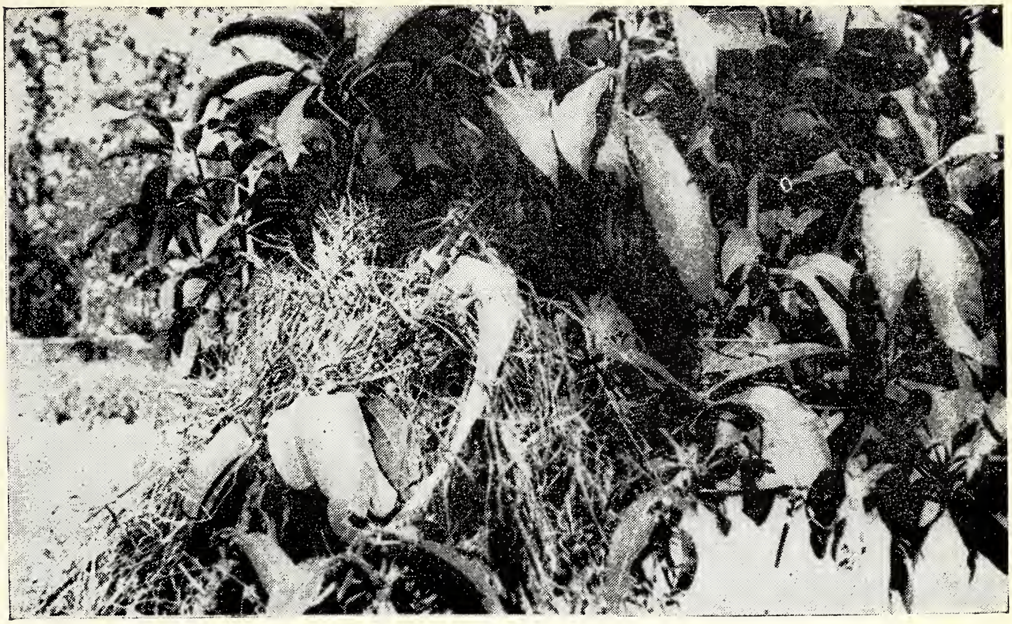

Fig. 1. The finished nest is a rough dome.

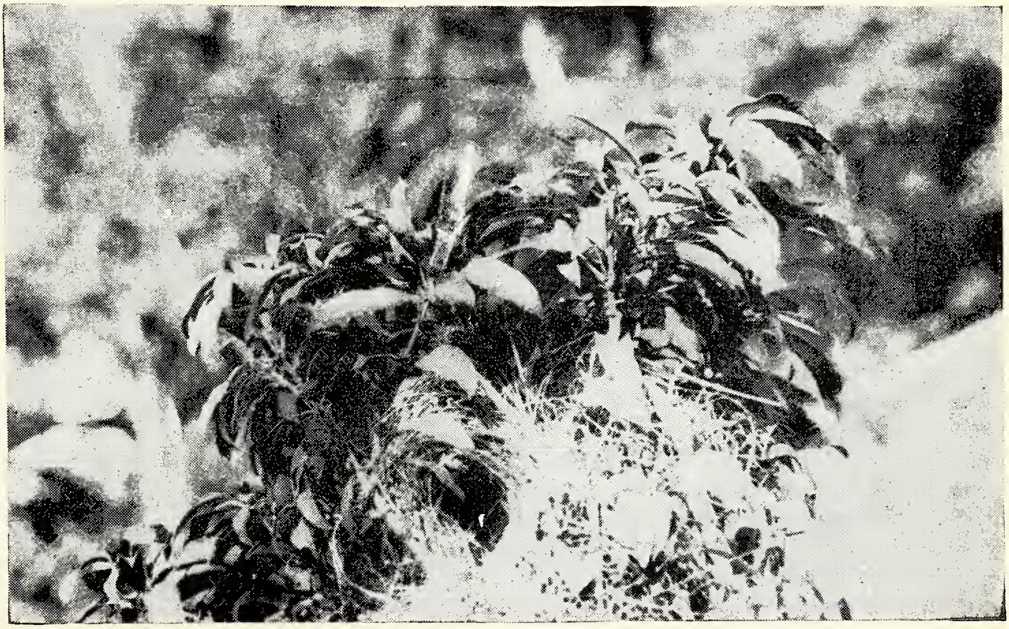

Fig. 2. The opening usually faces the fork.

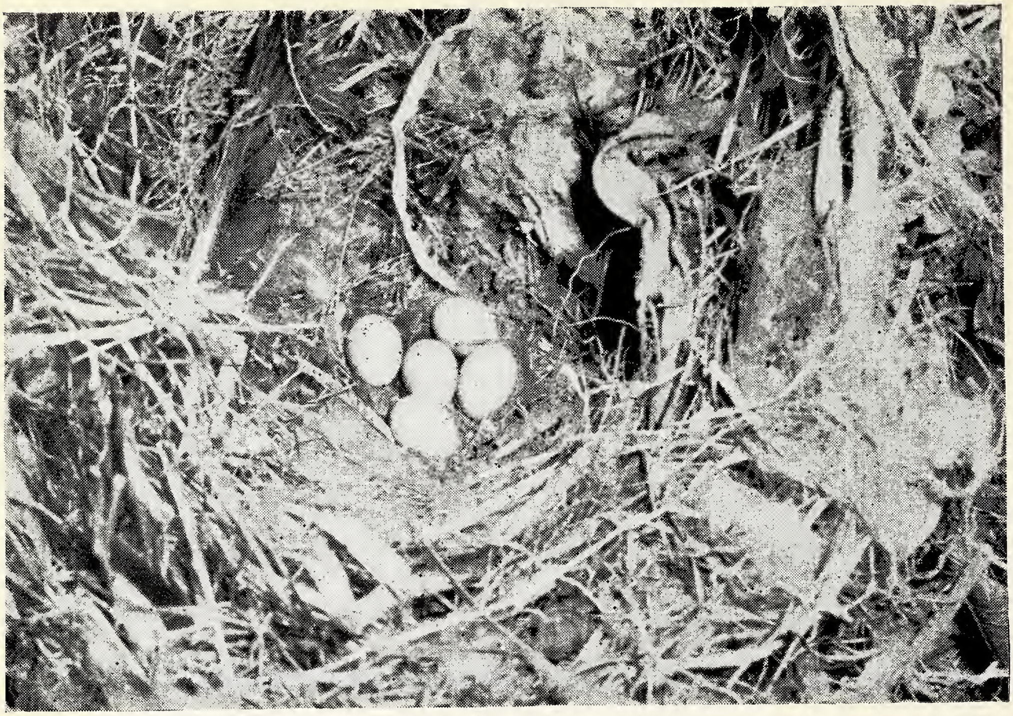

Fig. 3. The eggs are ovoid in shape and blue in colour.

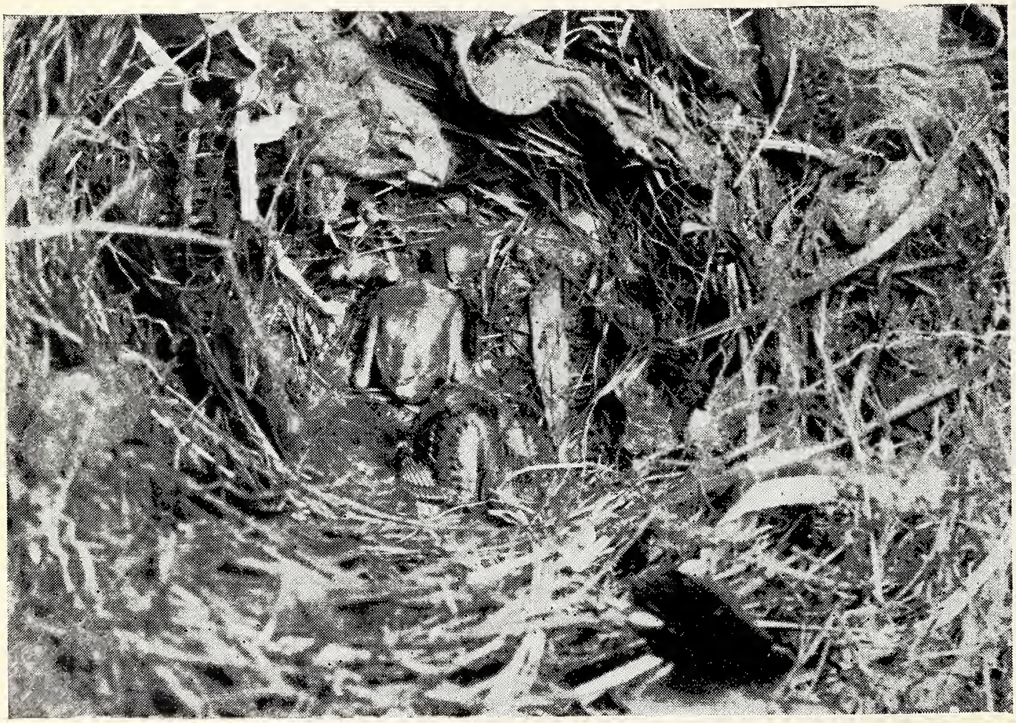

Fig. 4. One week old nestlings.

the eggs were laid during the afternoons. The individual time of laying and the period of twenty-four hours was, however, maintained in all cases.

Clutch size :

In all 172 clutches were observed during the period of study. Out of these, sixty-two (36.05%) consisted of 4 eggs each, seventy-three (41.44 %) of 5 eggs each and thirty-seven (21.49 %) of 6 eggs each. The larger clutches (of 6 eggs) were laid more frequently in the first half of the breeding season and the smaller (of 4 eggs) in the later half. In 88 nests where second broods were raised the same number of eggs were laid for the second brood also. The average clutch size was larger (4.9) in the year 1975 when the breeding season started early, and was comparatively smaller (4.8) in the year 1976 in which the breeding season commenced late.

Eggs :

The eggs of the Indian Pied Myna are ovoid in shape and blue in colour. The shade may vary slightly from clutch to clutch. The shell is fairly glossy and devoid of any markings (Plate II, Fig. 3). Average size of 60 eggs was found to be 27.24 × 20.12 mm. This compared favourably with Baker's (1933) average of 27.6 × 20.2 mm for 100 eggs. The eggs weigh from 4.974 grams to 6.391 grams. Average weight of forty eggs worked to be 5.937 grams.

Incubation :

The female starts incubating during the day time after the full clutch has been laid. She, however, starts spending the nights in the nest even a day or two before the laying of the 1st egg. Although she always sits in the nest during the night, from the laying of the first egg, it is doubtful if she incubates the eggs during the first one or two nights. This fact is revealed by the hatching pattern, and is discussed under that head.

The male hangs around the nest while the female is incubating. He may go for short feeding trips. On return from such trips he usually intimates his arrival to his spouse either by calling or peeping into the nest. He relieves her occasionally for short feeding trips. During this time he may stay in the nest or outside. It could not be ascertained whether or not he incubates during the time he is inside the nest.

On hot afternoons the female may leave the nest and join her mate in a shady branch of the nesting tree.

Period of incubation and hatching pattern :

The eggs hatch after 14-15 days (Table 11) more or less in the same order in which they are laid. The time gap between the laying of the last egg to the hatching of the same has been taken as period of incubation. Eggs hatch out at irregular intervals of four to twenty-four hours, the first two hatching out on the same day within six hours of each other. That indicates that the regular incubation does not get under way till the second or the third egg is laid.

Hatching success :

Hatching success was found to be fairly high. In the year 1975 it was observed to be 79% and in 1976 it was 88% (Table 12).

Nest life :

The hatchlings are fleshy, pink in colour and almost naked. They have a yellow bill and gape, tip of the bill hard and eyes closed. There are traces of greyish white filoplumes on the head, back, wings, thighs and sides of the abdomen. The hatchlings are unable to stand up. They gape for food shortly after hatching.

The newly hatched young are kept warm especially during the night by the mother. This

TABLE 11

PERIOD OF INCUBATION AND HATCHING PATTERN

Nest No.	Egg No.	Laid on	Hatched on	Period in days
2A—/75	1	25.5.75	9.6.75	15 days
	2	26.5.75	10.6.75 morn.	15 days
	3	27.5.75	10.6.75	14 days
	4	28.5.75	10.6.75 night	14 days
9/1/75	1	9.5.75	Unhatched	—
	2	10.5.75	25.5.75	15 days
	3	11.5.75	25.5.75 even.	15 days
	4	12.5.75	26.5.75	14 days
	5	13.5.75	Unhatched	—
9/2/75	1	1.7.75	damaged	—
	2	2.7.75	17.7.75	15 days
	3	3.7.75	17.7.75	14 days
	4	4.7.75	18.7.75	14 days
13/75	1	15.5.75	30.5.75	15 days
	2	16.5.75	31.5.75	15 days
	3	17.5.75	31.5.75	14 days
	4	18.5.75	1.6.75 even.	14 days
16/15	1	20.5.75	4.6.75 even.	16 days
	2	21.5.75	5.6.75	15 days
	3	22.5.75	5.6.75 even.	15 days
	4	23.5.75	damaged	—
	5	24.5.75	6.6.75 even.	14 days
18/75	1	25.5.75	damaged	—
	2	26.5.75	10.6.75	15 days
	3	27.5.75	10.6.75 even.	15 days
	4	28.5.75	Unhatched	—
	5	29.5.75	12.6.75 morn.	14 days
4/76	1	7.5.76	24.5.76	17 days
	2	8.5.76	24.5.76	16 days
	3	9.5.76	25.5.76	16 days
	4	10.5.76	25.5.76	15 days
	5	11.5.76	25.5.76 even.	15 days
	6	12.5.76	26.5.76	14 days
10/76	1	17.5.76	3.6.76	17 days
	2	18.5.76	3.6.76	16 days
	3	19.5.76	3.6.76	15 days
	4	20.5.76	4.6.76	15 days
	5	21.5.76	4.6.76	14 days
13/76	1	10.6.76	25.6.76 even.	16 days
	2	11.6.76	26.6.76	15 days
	3	12.6.76	26.6.76 even.	15 days
	4	13.6.76	27.6.76	14 days

TABLE 12

HATCHING SUCCESS

	Nest No.	No. of eggs laid	No. of eggs hatched	Total %
1975	2	4	4	
	6	5	did not hatch	
	9/1	5	3	
	9/2	4	3	
	13	4	4	
	16	5	4	nearly 79% (average)
	17	6	6	
	18	5	3	
	19	6	6	
	20	3	3	
1976	2	4	4	
	3	6	6	
	4	6	6	
	6	5	5	
	10	5	5	
	11	5	1	nearly 88% (average)
	13	4	4	
	14	5	4	
	15	5	5	
	16	4	3	

night brooding continues for about 16-18 days. Even when the hatchlings are about to fly the female spends the night with them in the nest. The young, especially in the earlier stages, are never left unguarded.

Both parents bring food and feed the young. The young are fed on insect larvae, soft bodied insects, spiders, etc. to begin with. Regurgitated grain is added to the bill of fare later. Both the parents are kept under great pressure by the constant demand of food by their 4 or 5 nestlings. As many as thirty to forty-four trips an hour by both parents were recorded on a number of occasions. In a six hour observation the feeding trips averaged to 35 trips an hour for a single pair.

The freshly hatched young weighs slightly less (average of thirty-two : 0.512 grams) than the egg's weight before hatching. The average individual weight gain recorded in 17 hatchlings was 4.371 grams per day in the first week, 3.889 grams per day in the second week and 3.473 in the third week. The average individual weight of hatchlings shortly before leaving the nest in the case of above-mentioned 17 fledglings was found to be 78.415 grams. The adult weighs between 86 and 95 grams.

The eyes open on the 7th or 8th day after hatching. The body feathers, remiges and rectrices also make their appearance by that time

(Plate II, Fig. 4). There is a gradual lengthening and growth of body feathers till the nestling is ready to fledge. The growth of remiges and rectrices is much faster than of the body feathers.

Fear complex develops a day or two after the eyes open. When the eyes are closed the nestlings will raise their necks and gape for food on the slightest disturbance outside the nest. After the opening of eyes the nestlings start discriminating between the visit of a parent and that of intruders. At about the same time they start responding to the alarm calls of the parents. On approach of an intruder or in response to the alarm call the nestlings move deep inside the nest and may even cling to the nest lining if handled. The parent offspring recognition also seems to be audiovisual. Even after leaving the nest when a few families are feeding in a group the young birds beg food from their own parents only. They do, however, equally respond to the alarm calls of others of the community.

The young leave the nest when they are about 3 weeks old (21-25 days). A few days before leaving the nest they come out of the nest and perch on nearby branches where they practice flying. Short practice flights are indulged before they accompany the parents for feeding on ground. How long the young remain with the parents before leaving the area was not studied.

Nesting success :

The nesting success worked out to be 57% in 1975 and 54% in 1976. Most deaths (31%) were due to fall on account of the nest being blown away by strong gusty winds during monsoons. The next important factor involved was perhaps the availability of food. In nests which did not meet with accidents it was found that some of the nestlings (17%) died especially from broods of 5 and 4 young. It is presumed that these deaths were on account of starvation. Some of these deaths may have occurred on account of other factors.

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A COMPARATIVE STUDY OF THE FEEDING HABITS OF CERTAIN SPECIES OF INDIAN BIRDS AFFECTING AGRICULTURE

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INTRODUCTION

The need for studying the biology of Indian birds in relation to agriculture and forestry was pointed out by Sálim Ali in 1936. Mason and Maxwell-Lefroy (1912), D'Abreu (1920), Hussain and Bhalla (1931, 1937 a & b), and Mukherjee (1966-1976), and a few others listed by Mukherjee (op.cit.) have worked on this problem.

From 1968 to 1972 the senior author (D. N. M.) carried out a preliminary study of the feeding habits of 10-15 species of birds affecting agriculture in India. From 1974 he continued a similar study on two species of babblers (*Turdoides* spp.) in collaboration with the other two authors. The results of these investigations form the basis for this paper.*

Material and Methods

Feeding habits and behaviour of wild birds were observed using binoculars.

Birds were collected with shot gun from the cultivated fields or adjoining areas from Rajampet Taluk, Cuddapah District of Andhra Pradesh, Nilambur in the Malappuram District, Mannarghat in the Palghat District, and near Palathu area in the Calicut District of Kerala. The stomach contents were preserved in 10% formalin. Some plants and animals were collected from the study area to help in identification. The plant materials in the stomach were identified at the Systematic Botany Section of Tamil Nadu Agricultural University and the animal material at the Madras Christian College and the University of Calicut. The food and feeding habits of 9 species of birds covered by this study are discussed below.

Results

1. Indian Pond Heron *Ardeola grayii* (Sykes)

This heron affects paddy fields at all stages of this crop but more often young paddy or stubble fields with water and those being prepared for planting. It feeds solitarily during day time and at dusk collects in large flocks to roost on trees in villages. In wind-damaged standing crops of paddy this bird fed in company with birds like the Common Myna the Black Drongo and the Baya. The food of Pond Heron appears to consist mainly of crabs, nymphs of dragonflies, grasshoppers and tadpoles. It takes adult frogs also. A leech *Herpobdelloides* sp. found in the food of a bird at Reddipalli has not been recorded in the food of Pond Herons. D'Abreu (1920) observed crickets in the diet of Pond Herons. Mukherjee (op.cit.) examined 105 adult specimens in the Sunderban area and found crustacea and aquatic vegetable matter to be the more important items in the diet of this heron. Tadpoles and adults of frogs, toads, small fishes and freshwater molluscs came next. Mukherjee (op. cit.) considered this bird to be economically harmless. A comparison of the stomach conents of the Pond Herons from the Sunderbans with those from Cuddapah and Palghat districts reveals that the birds of these regions had 10 families and 5 genera of prey animals in common. They differed in the absence of crickets (family Gryllidae) in the Sunderbans birds and molluscs in the southern Indian ones.

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* Based partly on the thesis by the first author which was accepted by the University of Bombay for the Ph.D. degree 1972.

The results of analyses of stomach contents of the thirty birds collected (four from Nilambur, seven from Mannarghat and nineteen from Rajampet taluk), are presented in Table 1.

2. & 3. **Little Brown Dove** *Streptopelia senegalensis* (Gmelin) & **Spotted Dove** *Streptopelia chinensis* (Gmelin).

Both species of doves were found in Cuddapah District where the Little Brown Doves fed in the open fields, fallows and cart tracks, and the Spotted Doves in the stubble fields fringed by trees, forests, and orchards. Only the latter species was observed in Palghat, Malappuram and Calicut Districts where it occurred in the rain forests as well as in the open areas around buildings. Both doves consumed some newly sown grains and it was perhaps for this reason that Hussain and Bhalla (1937b) considered the Little Brown Dove as injurious to agriculture.

In the periods after harvest and before sowing, the activities of these doves are perhaps entirely beneficial in destroying thousands of weed seeds. Their potential for disseminating weed seeds was not tested, e.g. by sowing seeds from excreta. Thirty specimens of the Little Brown Dove and thirty-one of the Spotted Doves were examined. Their stomach contents showed almost complete overlap in the major items consumed, among which the cultivated grains dominated. The items of food identified from the stomach contents of these two doves are given in Table 2.

TABLE 1

THE STOMACH CONTENTS OF 30 POND HERONS

Item of food	Common names	Frequency**	Remarks
Phylum Annelida Class Hirudinea Family Gnathobdellidae	leeches	1	*Herpobdelloides* sp. 16 leeches were found in a single stomach of a bird collected from a muddy rice-field.
Phylum Arthropoda Class Crustacea Order Decapoda Family Potamonidae	crabs	6	*Paratelphusa* sp.
Class Arachnida Order Araneae Family Lycosidae	spiders	6	*Pardosa* sp. *Lycosa indagastrix.*
Class Insecta Order Orthoptera Family Blattidae	cockroaches	4	*Phyllodromia humbertiana*, *Blatta* sp.

** Frequency — The number of birds in the total sample examined which had taken the category of food indicated.

TABLE 1—(*Contd.*)

Item of food	Common names	Frequency**	Remarks
Family Acridiidae	grasshoppers	11	*Chrotogonus* sp. *Acridium* sp. *Tryxalis turrita.*
Family Gryllidae	crickets	11	*Gryllotalpa africana,* *Brachytrypes achatinus,* *Liogryllus* sp.
Order Hemiptera	bugs	5	Family Corixidae *Corixa* sp. Family Nepidae *Laccotrephes* sp.
Order Odonata Suborder Anisoptera	dragonflies	21	Dragonfly nymphs were the most frequent item in stomachs of paddy birds.
Suborder Zygoptera	damsel flies	2	
Order Neuroptera	caddis fly	1	
Order Coleoptera	beetles	18	Break-up in families : Dytiscidae 10, Gyrinidae 2, Hydrophilidae 5, Elateridae 1, Tenebrionidae 1, Scarabaeidae 1, Grub of *Cybister* sp.
Order Diptera	flies	10	Break-up in families : Tabanidae 4, Syrphidae 3, Stratiomyidae 3. Species : *Eristalis* sp. (Larvae), *Sphaerodema* sp.
Order Hymenoptera Family Formicidae	ants	3	*Camponotus* sp.
Phylum Chordata Class Amphibia Order Anura Family Ranidae	frogs	8	Adult of *Rana tigerina* was present only once. Rest were tadpoles.
Class Pisces Order Physostomi Family Cyprinidae	fish	1	*Barbus* sp.

** Frequency—The number of birds in the total sample examined which had taken the category of food indicated.

Table 2

Stomach Contents of Little Brown Dove and Spotted Dove

Item of food (Scientific names of plants)	Frequency	
	30 *Streptopelia senegalensis*	31 *S. chinensis*
Argemone mexicana	—	1
Borreria hispida	—	5
Phaseolus trilobus	11	3
Arachis hypogaea	3	—
Azima tetracantha	—	1
Coldenia procumbens	—	1
Sesamum indicum	5	2
Convolvulaceae seeds	2	—
Anisomeles indica	1	1
Amaranthus spinosus	1	—
Croton sparsiflorus	20	6
Phyllanthus maderaspatensis	3	8
Chrozophora rottleri	3	—
Cyanotis cucullata	1	—
Commelina benghalensis	—	1
Fimbristylis miliacea	1	2
Brachiaria ramosa	1	1
Digitaria marginata	—	2
Echinochloa colona	9	—
E. crus-galli	2	—
Euphorbiaceae seeds	2	2
Eleusine coracana	9	5
Oryza sp.	22	20
Paspalum scrobiculatum	—	14
Paspalidium flavidum	1	—
Pennisetum typhoideum	2	4
Setaria italica	9	4
Sorghum sp.	1	—
Panicaceae seeds	—	9
Animals Phylum Mollusca shells (traces)	2	3

It was not surprising that paddy the most commonly cultivated crop was also the most frequent item of food in both doves. There were very few grasslands in the area of collection. Among the wild seeds the Little Brown Dove ate more of the seeds of *Croton sparsiflorus* and the Spotted Dove seeds of *Paspalum scrobiculatum*. Their preference for wild seeds may thus differ.

4. **Indian Roller** *Coracias benghalensis* Linnaeus

Rollers were observed only in very small numbers in the cultivated fields where they usually perched on telegraph wires and trees and looked out for prey. They nested in holes in the trunks of tall Palmyra and Date palms growing in the midst of rice-fields and were thus associated with agriculture all round the year.

The wide variety and large quantities of food consumed by them included many animal groups which were pests of agriculture and forestry. A single individual consumed 120 soldiers and workers of termites, and another, 13 specimens of *Liogryllus bimaculatus*. These numbers probably represented only the quantity taken in one feeding session. This roller was recorded as very beneficial to agriculture by Mason and Maxwell-Lefroy (1912) and Hussain and Bhalla (1937). In the 17 samples of Roller stomachs examined beetles, grasshoppers and crickets were the most frequent items. Table 3 gives the items of animals found in the stomach contents.

5. **Small Green Bee-eater** *Merops orientalis* Latham

Very common bird in the cultivated areas and around human habitation. It likes bathing in soft sand and perching on telegraph wire, and assembles in fields and gardens in large flocks. This bee-eater roosts communally on small trees at spots far away from houses. It hunts insects in the air as well as on ground. From perches close by this bee-eater flies long distances parallel and close to the surface of crops, in search of food, returns to the perch hammers the prey on a wire or branch and swallows the prey like dragonflies head first. In the specimens examined it shared 10 orders and 13 families of insect prey with the Black Drongo.

It consumed a lot of hymenopterans but adult forms of Coleoptera, Odonata, and Lepidopetra were equally numerous in its food. Hussain and Bhalla (1937b) recorded this species to feed on moths and grasshoppers. The 32 specimens examined from the taluks of Mannarghat and Rajampet had taken the items of prey given in Table 4.

In Palghat (at Karimba) the Chestnut Headed Bee-eater *Merops leschenaulti* Vieillot also occurs with *M. orientalis*. To compare the diets of these two species, 9 specimens of the former and 10 of the latter were collected from a mixed roost during 3-7 January 1970.

It was found that *M. leschenaulti* consumed more dragonflies and red ants and *M. orientalis*, more ground beetles and more species of Coleoptera, Diptera, and Hymenoptera. Both species fed on Noctuidae and Chrysididae to harmful species of insects.

6. **Black Drongo** *Dicrurus adsimilis* Vieillot

This drongo affects fields of paddy and bajra in flocks of up to 16 birds at all stages of cultivation and in greater numbers if food is abundant. In a stink-bug infested rice field at Karimba 13 Black Drongos made 72 attacks on this bug within 80 minutes. In 9 birds collected from this field on that day 160 heads of *Leptocorixa acuta* were counted from stomach contents. D'Abreu (1920) and Hussain and Bhalla (1931 and 1937b) found this drongo feeding on grasshoppers and locusts.

This species perches close to its prey and appears to swoop down after seeing it. Clashes with the Green Bee-eaters were observed. A Chrysomelid beetle (*Sindia clathrata*) was taken by this drongo and the Chestnut Headed Bee-eater. When paddy is being harvested this drongo feeds in close association with the Common Myna capturing the insects flushed out by the latter bird. The Black Drongos and the Common Mynas shared insects of 6 orders and 16 families. This drongo feeds in the twilight period also.

In 33 specimens of the Black Drongo collected from Nilambur (2), Mannarghat (18) and Rajampet (13) taluks the items of food given in Table 5 were identified.

7. **Common Myna** *Acridotheres tristis* (Linnaeus)

The most common bird of agricultural areas. Thirty to sixty birds moved together and fed from ground, in ploughed fields, stubble

TABLE 3

STOMACH CONTENTS OF 17 SOUTHERN INDIAN ROLLERS

Item of food	Frequency	Remarks
Phylum Arthropoda		
Class Insecta		
Order Orthoptera		
Family Blattidae	6	*Corydia* sp., *Blatta* sp.
Family Acridiidae	12	*Hieroglyphus* sp. *Atractomorpha* sp. *Chrotogonus* sp. *Tryxalis* sp. *Acridium* sp. *Epacromia dorsalis.*
Family Gryllidae	10	*Gryllotalpa africana,* *Liogryllus bimaculatus,* *Gryllus domesticus,* *Schizodactylus* sp.
Order Hemiptera		
Family Belostomatidae	1	
Family Coreidae	2	
Order Isoptera		
Family Termitidae	2	*Eutermes obesus*
Order Odonata		
Suborder Anisoptera	1	
Suborder Zygoptera	1	
Order Coleoptera Beetles	14	Break-up in families : Carabidae 4, Dytiscidae larva 1, Buprestidae 1, Cleridae 1, Meloidae 1, Bruchidae 1, Chrysomelidae 6, Curculionidae 5, Scarabaeidae 6, Melolonthidae 3, grub of Cerambycidae 1, Species : *Sphenoptera* sp. *Eudema angulatum, Tenebrio* sp.
Order Lepidoptera (Caterpillars only)	2	
Order Hymenoptera		
Family Evanidae	2	*Evania appendigaster, Polistes* sp.
Family Formicidae	2	*Oecophylla* sp.
Class Myriapoda		
Order Chilopoda		
Family Scolopendridae	2	*Scolopendra* sp.
Phylum Chordata		
Class Amphibia		
Order Anura		
Family Ranidae	5	
Family Bufonidae	4	
Class Reptilia		
Order Lacertilia		
Family Scincidae		
Genus Mabuya	1	

TABLE 4

STOMACH CONTENTS OF 32 SMALL GREEN BEE-EATERS

Item of food	Frequency	Remarks
Phylum Arthropoda Class Insecta Order Orthoptera		
Family Blattidae	3	*Corydia petiveriana, Blatta* sp.
Family Acridiidae	6	
Family Tettigoniidae	1	
Family Gryllidae	2	
Order Hemiptera		
Family Pentatomidae	2	
Family Reduviidae	1	
Family Capsidae	1	
Family Corixidae	1	*Corixa* sp.
Order Isoptera	2	
Order Odonata		
Suborder Anisoptera	16	2 families, 2 species : *Aeschna* sp., *Libellula* sp.
Suborder Zygoptera	5	
Order Coleoptera	20	Break-up in families : Cicindelidae 1, Carabidae 3, Staphilinidae 1, Dermestidae 2, Bostrichidae 1, Buprestidae 2, Tenebrionidae 4, Bruchidae 1, Chrysomelidae 10, Curculionidae 2, Scarabaeidae 3, Species : *Scarites, Coprinus, Coptocycla, Zonabris pustulata, Sindia clathrata.*
Order Neuroptera		
Family Mantispidae	1	
Order Lepidoptera		
Family Noctuidae	11	*Cirphis albistigma*
Order Diptera	19	Break-up in families : Psychodidae 1, Simulidae 1, Tabanidae 4, Asilidae 1, Syrphidae 2, Muscidae 3, Panorpidae 1, Calliphoridae 4, Species : *Musca domestica, Panorpa* sp., *Asilus* sp., *Lucilia* sp.
Order Hymenoptera		
Family Ichneumonidae	2	
Family Evaniidae	5	*Evania appendigaster*
Family Chrysididae	3	
Family Mutillidae	1	
Family Eumenidae	1	*Eumenes conica*
Family Vespidae	5	*Vespa orientalis*
Family Apidae	21	*Apis indica* 5, *Apis florea* 4, *Zylocopa* sp. 1, *Mellipona* sp.
Family Formicidae	11	*Camponotus* 6, *Oecophylla* 1, *Dorylus* 1, *Diacamma* 1.

TABLE 5

STOMACH CONTENTS OF 33 BLACK DRONGOS

Item of food	Frequency	Remarks
Phylum Arthropoda		
Class Arachnida		
Order Araneae	2	Families Argiopidae, Oxyopidae
Class Insecta		
Order Orthoptera		
Family Blattidae	2	*Blatta* sp.
Family Mantidae	4	
Family Acridiidae	13	*Acridium* sp.
Family Tettigonidae	3	
Family Gryllidae	5	*Gryllus* sp.
Order Hemiptera	18	Families : Pentatomidae 8, Coreidae 9, Pyrrhocoridae 1, Reduviidae 3. Species : *Bagrada picta* and *Leptocorixa acuta.*
Order Isoptera		
Family Termitidae	2	*Eutermes obesus.*
Order Odonata		
Suborder Anisoptera	6	Genera *Aeschna* and *Anax*
Suborder Zygoptera	4	
Order Neuroptera	6	
Order Coleoptera	26	Families : Cicindelidae 5, Carabidae 7, Gyrinidae 1, Cantharidae 1, Buprestidae 4, Elateridae 2, Tenebrionidae 6, Chrysomelidae 8, Curculionidae 1, Lucanidae 1. Species : *Omphra* sp. *Onthophagus* sp. *Sindia clathrata.*

TABLE 6

STOMACH CONTENTS OF 32 COMMON MYNAS

Item of food	Frequency	Remarks
Phylum Arthropoda		
Class Arachnida		
Order Araneae	2	Family : Thereididae
Class Insecta		
Order Orthoptera		
Family Blattidae	4	Species : *Phyllodromia humbertiana, Blatta* sp.
Family Acridiidae	15	*Acridium* sp. *Cyrtacanthacris* sp. *Epacromia* sp.
Family Gryllidae	1	
Order Dermaptera	2	
Order Hemiptera	8	Families : Pentatomidae, Coreidae, Reduviidae, Tingidae.
Order Isoptera (Termites)	7	*Eutermes obesus*
Order Odonata	5	
Order Coleoptera	21	Families : Cicindelidae 1, Carabidae 2, Staphilinidae 3, Buprestidae 2, Elateridae 1, Tenebrionidae 4, Chrysomelidae 8, Curculionidae 1, Scarabaeidae 14. Species : *Gonocephalum hoffmanseggi, Sphenoptera perrotteti, Cosmopolitus sordidus, Scarites* sp.
Order Lepidoptera	1	Butterfly
Order Hymenoptera		
Family Ichneumonidae	1	
Family Apidae	1	
Family Formicidae	7	*Camponotus compressus*
Phylum Chordata		
Class Amphibia		
Order Anura		
Family Ranidae	1	Bones of frog
Plants Seeds of Species :		
Azima tetracantha	1	
Ehretia microphylla	7	
Melia azadarachta	1	
Lantana spp.	4	
Fluggea leucopyrus	1	

and grasslands. In rice-fields near Nilambur gatherings of 200-300 Common and the Jungle Mynas *Acridotheres fuscus* fed and roosted together. The Common Mynas took a number of weed seeds. Both species took large quantities of beetles and had 16 families of insects prey in common. Mason and Maxwell-Lefroy (1912), D'Abreu (1920) and Hussain and Bhalla (op.cit.) all found the Common Myna to be beneficial to agriculture. The items of food given in Table 6 were found in thirty-two specimens of the Common Myna examined from Nilambur, Mannarghat and Rajampet.

The Jungle Myna which was found in the more hilly parts of Nilambur and Mannarghat had many items of food in common with the Common Myna. The stomach contents of 12 Specimens of the Jungle Myna collected for comparison are given in Table 7.

8. **Whiteheaded Babbler** *Turdoides affinis* Jerdon

Groups of Whiteheaded Babblers varying in number from 1-16, fed in kitchen gardens, cashew groves, coconut plantations, gardens of turmeric, ginger, bajra, cassava, peppervine, peas, standing crops of paddy and bajra, and in thickets of Lantana. Its typical feeding niche is among the dead leaves on ground but it can feed in a variety of situations and on a wide range of vertebrate and invertebrate animal, and vegetable food. Since it consumes grains of rice, jowar, and bajra it is considered to be a pest of these crops by some farmers. Examination of stomach contents of over a hundred specimens collected throughout the year suggests that this species does not consume any particular item of food in large quantities so as to be classified as a pest.

The closely related Jungle Babbler *Turdoides striatus* occurs sympatrically with *T. affinis* in many places. The larger and darker Jungle Babblers are more widely distributed in India. At Baroda, Andrews and Naik (1970) found the Jungle Babblers living close to houses but only in areas with plenty of trees and bushes. In the Calicut area they do not come into the open spaces as much as *T. affinis*. Both species visit the premises of houses and buildings but the shady kitchen gardens with tall trees and bushes which keep the surroundings poorly lit show more Jungle Babblers. These two species exhibit almost a complete overlap in their items of food. Both species consume unconventional items like the fruits of mango, jack-fruit, cassava, starch and the cashew, apple and staple items like grasshoppers, termites, and beetles. In the stomach contents of 17 specimens of the *Turdoides affinis* collected from Palghat and 14 collected from Rajampet the items of food given in Table 8 were identified.

Near Calicut both types of babblers consume consistantly small quantities of the tubers of cassava and termites. The role of these babblers in the control of termites in Malabar is worth investigating. At Baroda, Andrews & Naik (1970) found the Jungle Babbler to feed largely on insects particularly coleopterans and quoted Rana (1970) who found this bird taking large quantities of food grain in summer and winter at Jodhpur.

9. **Large Pied Wagtail** *Motacilla maderaspatensis* (Gmelin)

This wagtail is associated with agriculture in almost every stage of its life. It feeds in the muddy inundated paddy fields or on the grass covered bunds. At Reddipalli it was observed nesting in a well and at Karimba, on a rock jutting out of a rivulet, flowing through a rice field. The 22 specimens examined, 11 each from Reddipalli and Karimba had fed upon the items of food shown in Table 9.

In the limited samples examined, Coleoptera, Orthoptera, Odonata, and Diptera were more numerous. D'Abreu (op.cit.) found grasshoppers and crickets in the stomach contents of this wagtail in the central provinces.

TABLE 7

STOMACH CONTENTS OF 12 JUNGLE MYNAS

Item of food	Frequency	Remarks
Phylum Arthropoda		
Class Arachnida		
Order Araneae	1	Families : Heteropodidae 1, Argiopidae 1.
Order Acarina	1	Tick *Acarina* sp.
Class Insecta		
Order Orthoptera		
Family Blattidae	2	*Blatta* sp.
Family Acridiidae	7	*Tryxalis turrita*, *Chrotogonus* sp.
Order Hemiptera		
Family Pentatomidae	1	
Order Isoptera		
Family Termitidae	2	*Eutermes* sp.
Order Odonata		
Suborder Anisoptera	2	
Suborder Zygoptera	1	
Order Neuroptera	1	
Order Coleoptera	10	Break-up in Families : Cicindelidae 1, Carabidae, Staphylinidae 4, Dermestidae 1, Bostrichidae 1, Cantharidae 1, Lampyridae 1, Buprestidae 3, Elateridae 1, Tenebrionidae 3, Chrysomelidae 6, Melolonthidae 1, *Cicindela* sp. *Gonocephalum hoffmanseggi**.
Order Hymenoptera		
Family Apidae	1	*Apis florea*
Family Formicidae	2	*Camponotus* sp.
Plant (seeds) *Lantana* sp.	5	
Compositae	2	Total insect families taken by *A. fuscus* : 24; Total families of prey common between *Acridotheres tristis* & *A. fuscus* : 16.

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* Also taken by *Acridotheres tristis*.

TABLE 8

STOMACH CONTENTS OF 31 WHITEHEADED BABBLERS

Item of food	Frequency	Remarks
Phylum Arthropoda Class Arachnida Order Araneae	5	Families : Heteropodidae, Argiopidae, Clubionidae. *Heteropoda* sp.
Order Orthoptera Family Blattidae	13	*Blatta orientalis,* *Phyllodromia humbertiana*
Family Acridiidae	13	*Acridium* sp. *Chrotogonus* sp.
Family Gryllidae	15	*Gryllotalpa* sp. *Schizodactylus* sp. *Gryllus* sp.
Order Hemiptera	5	Families : Pentatomidae, Coreidae, Reduviidae, Capsidae, Membracidae.
Order Isoptera Family Termitidae	7	
Order Odonata Suborder Anisoptera	2	
Suborder Zygoptera	2	
Order Neuroptera	5	
Order Coleoptera	28	Families : Cicindelidae 6, Carabidae 11, Staphylinidae 1, Coccinellidae 1, Dermestidae 1, Bostrichidae 1, Elateridae 3, Tenebrionidae 15, Chrysomelidae 12, Cerambycidae 5 (larvae), Curculionidae 5. *Cicindela* sp. *Tenebrio molitor,* *Mesomorpha villiger, Hispa armigera.*
Order Lepidoptera	2	Family : Sphingidae 1
Order Diptera	1	Family : Asilidae
Order Hymenoptera Family Apidae	1	
Family Vespidae	1	
Family Formicidae	1	*Camponotus* sp.
Class Myriapoda Order Chilopoda Family Scolopendridae	1	*Scolopendra* sp.
Plants, seeds of species :		
Pennisetum typhoideum	1	
Azima tetracantha	1	
Physalis minima	2	
Lantana sp.	8	
Passiflora sp.	3	

TABLE 9

THE STOMACH CONTENTS OF THE LARGE PIED WAGTAIL

Item of food	Frequency	Remarks
Phylum Arthropoda Class Arachnida Order Acarina	1	*Acarina* sp.
Class Insecta Order Orthoptera Family Blattidae	6	*Blatta* sp., *Phyllodromia humbertiana.*
Family Acridiidae	9	*Chrotogonus* sp., *Acridium* sp.
Family Gryllidae	4	*Tridactylus* sp.
Order Dermaptera	3	
Order Hemiptera Family Reduviidae	1	
Family Cicadidae	1	
Order Isoptera Family Termitidae	1	
Order Odonata Suborder Anisoptera	5	Adults 3, nymphs 2.
Suborder Zygoptera	3	Adults
Order Neuroptera	2	
Order Coleoptera	19	Break-up in Families : Cicindelidae 2, Carabidae 4, Dytiscidae 1, Gyrinidae 3, Staphylinidae 1, Silphidae 1, Cleridae 2, Tenebrionidae 7, Elateridae 5, Chrysomelidae 4, Cerambycidae 2, Curculionidae 5. Species *Scarites indus*, *Coprinus* sp., grub of Bostrichidae 1.
Order Lepidoptera	1	Pupa
Order Diptera	6	Break-up in families : Stratiomyidae 1, Muscidae 1, Sarcophagidae 1, Dipteran larvae, Chironomus larvae 1.
Order Hymenoptera, Evaniidae (wasps)	2	*Evania appendigaster*
Family Apidae (bees)	1	
Family Formicidae (ants)	2	*Solenopsis* sp., *Oecophylla* sp.

The Pied Wagtails were not found in large numbers and were often seen close to rivers, ponds and inundated fields. The food habits of the migratory wagtails which visit India every year will also be very interesting as they frequent the paddy and sugar-cane fields in enormous numbers.

A Comparison of Feeding habits

Data such as these presented above could be used to understand how different species of related and unrelated birds with comparable feeding habits co-exist in an area, and to have some preliminary facts about the food requirements of these species before planning research in economic ornithology.

Gause's principle that two species cannot co-exist indefinitely if they are limited in their population sizes by the same factors can be interpreted to mean that the two similar species of animals or birds co-existing in the same environment (normally) must take different foods. How far this principle is applicable in the food requirements of some of the common species of Indian birds may also be examined to a very limited extent with the data presented here.

The Pond Heron was useful to agriculture in destroying grasshoppers, crickets and flies but it also consumed vast quantities of useful forms like dragonfly nymphs and tadpoles. It was the only heron (Ardeidae) consistently observed in rice-fields. Mason and Maxwell-Lefroy (op.cit.) considered the Pond Heron as useful to agriculture.

Winged forms like the adult dragonflies and moths like *Cirphis albistigma* were frequently eaten by the Indian Small Green Bee-eater. This bee-eater consumed some bees and other hymenopterans but did not specialise on a diet of bees. About half of the 38 families of insects found in the food in the bee-eaters examined was injurious to agriculture. It roosted near rice-fields and clashed with the Black Drongo with which it had many families of prey in common.

Bugs, e.g. *Leptocorixa acuta* were very frequent in the Black Drongo and rare in the food of bee-eaters. Sixty per cent of the 28 families of insect food in the Black Drongo stomachs were injurious to agriculture. It never gathered in large flocks. The entire biology of this species merits thorough investigation. Fletcher (1914) suggested how this bird could be encouraged to feed from cultivated fields by offering it more perches. This could be done by growing crops with larger shoots like castor as a side crop along the margins of fields holding crops like paddy and millet. This drongo does not occur in large numbers and it will be advisable not to kill it in numbers even for study purposes.

The Common Myna which was more abundant in the rice fields than the above species took many ground beetles and 53% of the animal food in the samples studied came from the harmful families of Orthoptera, Isoptera, Coleoptera, and Hymenoptera. Grasshoppers, cockchafers, leaf beetles, and termites were the more frequent items in that order. Mason and Maxwell-Lefroy (1912) stressed the importance of this myna to agriculture as an enemy of insect pests.

The Roller which is larger in size than the birds discussed so far seemed to have a wider range of food articles. It fed on the ground, but after watching carefully from perches on telegraph wires and trees in the midst of cultivated fields. Mason and Maxwell-Lefroy found the roller to be beneficial to agriculture and seven species of crickets and grasshoppers reported by them as prey of rollers were found in the samples examined in the present study. The Roller's food included vertebrates like frogs, toads, and *Mabuya*.

In diet and habits the Large Pied Wagtail came closest to the Pond Heron. Coleopterans were prominent in the diet of this Wagtail followed by Orthoptera and Odonata. The sample examined contained more injurious than useful families of insects.

The Whiteheaded Babbler had the widest range of food items including many cultivated and wild seeds and fruits and nearly all of the items of invertebrate food taken by the other carnivorous and insectivorous species of birds examined by us. In consuming some of the food crops of man it may be described as potentially harmful to human interests but it never took any single item of food in very large quantities and the injurious families of animals taken by it outnumbered the beneficial and neutral ones. Its diet almost completely overlapped that of the Jungle Babbler from which it differed in coming out more often into open fields, grasslands and lawns.

Cultivated grains like paddy and ragi were the chief food of the Little Brown and Spotted Doves. The latter is more widely distributed. The limited data available suggests that these two species may have different preferences for wild seeds, e.g. *Croton sparsiflorus* in the Little Brown and *Paspalum scrobiculatum* in the Spotted Dove. These doves can damage freshly sown paddy and millets but the fact that they consume almost exclusively vast quantities of weed seeds is noteworthy. Only detailed year-round studies of annual diets will reveal their exact economic status. In table 10 the economic importance of the food of some of the species discussed here is compared. The classification of invertebrate food into harmful beneficial etc. is based on Mason and Maxwell-Lefroy (1912).

The Baya Weaver bird (*Ploceus philippinus*)

TABLE 10

COMPARISON OF THE ECONOMIC IMPORTANCE OF PREY OF 7 SPECIES OF BIRDS

Species of birds	*Ardeola grayii*	*Merops orientalis*	*Coracias benghalensis*	*Acridotheres tristis*	*Dicrurus adsimilis*	*Turdoides affinis*	*Motacilla maderaspatensis*
Number of samples ..	30	32	16	32	33	30	22
Number of families of animal food ..	23	38	24	24	28	24	28
1. Accumulated totals of occurrence of injurious families ..	34	72	41	47	66	91	39
2. Accumulated totals of occurrence of beneficial families ..	53	61	19	5	27	24	10
3. Accumulated totals of neutral families ..	30	14	18	36	18	12	31
Grand Total of 1, 2 & 3 ..	117	147	78	88	111	127	80

The economic status of insect families is taken from Mason and Maxwell-Lefroy (1912).

shares the same habitat as the birds discussed above, and consumes many of the items of food taken by them. In the nestling stage the Baya is omnivorous consuming grains as well as insects like grasshoppers and caterpillars, but as adult its diet comes close to that of a dove. The Baya takes seeds from the ground as well as directly from the panicles of standing Paddy and Bajra ; but it avoids Ragi. The doves consume large quantities of Ragi but being too heavy to perch on the plants, they have to pick up grains from the ground or from plants blown down by wind (Mathew 1977).

The data presented in this paper throw some light on how different species of birds with comparable diets adjust with each other with respect to food. Viewed from a broad taxonomic level like that of the order (of the prey animal) there does not appear to be any strict one predator one order of prey relationship between the birds examined and their food animals. All the carnivorous-omnivorous species studied by us consumed members of coleoptera and orthoptera. But each species had some family of insects on which it preyed consistently, and a feeding behaviour suitable for capturing that group. The Pond Herons which fed walking slowly through the rice fields and watching the ground carefully took more of odonata nymphs, coleoptera and diptera larvae (Tables 11 & 12). The actively flying Small Green Bee-eater and the Black Drongo took many flying insects (Tables 4, 5, 11 & 12). But the latter consumed more of bugs and the former more hymenopterans.

The Common Mynas and the Whiteheaded Babblers had many plant and animal items of prey in common but the Babbler's special feeding niche was leaf litter on the ground and special items of food cockroaches and termites (tables 6, 8 & 11). The Common Myna depended much on grasshoppers and ants. Both consumed coleoptera but the babblers took a wider range of beetles (Tables 11 & 12).

When one compares the different families of a particular order of insects for example coleopterans consumed by birds it is found that there is much more difference between the prey animals taken (table 12) than is apparent if one were to make a comparison at the order level of prey. The order of importance as prey of the different families of beetles to seven species of birds is brought out further in table 13. Thus the different species of birds which are associated with agriculture and which are found in the same habitat have different combinations of food requirements which keep their niches distinct. Gause's Principle is generally applicable to the dietary needs of the birds examined here. The cases studied here also illustrate the fallacy of classifying a bird as a pest before studying its food habits in different seasons and population size in detail. In many cases the potential of Indian birds for controlling pests of agricultue is underestimated or not known at all.

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TABLE 11

A COMPARISON OF THE STOMACH CONTENTS OF 7 SPECIES OF BIRDS AFFECTING AGRICULTURE

PREY ANIMALS AND PERCENTAGE OF BIRDS OUT OF A SAMPLE OF 30 FROM EACH SPECIES CONSUMING EACH ITEM

Species of birds	Cockroaches	Grasshoppers	Crickets	Termites	Dragonflies	Bugs	Butterflies and moths	Flies	Beetles	Bees	Frogs
Pond Heron ..	13.0	36.6	36.6	—	70.0	16.6	—	33.3	60.0	—	26.7*
Indian Roller* 1 ..	35.3	70.6	58.2	11.8	6.0	17.6	11.8	—	82.3	—	29.4
Small Green Bee Eater	9.3	21.9	6.2	6.2	50.0	15.6	34.4	59.3	62.5	65.6	—
Black Drongo ..	6.0	48.4	15.0	6.0	18.9	54.5	—	9.1	78.7	9.1	—
Common Myna ..	2.5	46.8	3.1	21.8	15.6	25.0	3.1	—	65.6	3.1	3.1
Whiteheaded Babbler	41.9	41.9	25.8	22.5	6.4	16·1	6.4	3.2	90.9	3.2	—
Large Pied Wagtail *2	27.2	40.9	18.1	4.5	18.0	13.6	4.5	27.2	86.3	4.5	—

*1-2 made up to 30

*25% Tadpoles

Species of birds	Leech	Crab	Spider	Mantis	Earwigs	Damselflies	Neuroptera	Wasps	Ants	Centipedes	Toads	Skink
Pond Heron	3	20.0	20.0	—	—	6.7	—	—	—	—	—	—
Indian Roller	—	—	—	—	—	6.0	—	11.8	11.8	11.8	23.5	6.0
Small Green Bee-eater ..	—	—	—	—	—	15.6	3.2	53.1	34.4	—	—	—
Black Drongo	—	—	6.0	12	—	12.0	3.0	9.1	33.0	—	—	—
Common Myna	—	—	6.2	—	6.2	3.1	3.0	3.0	21.8	—	—	—
Whiteheaded Babbler	—	—	16.1	—	—	6.4	16.1	3.2	3.2	3.2	—	—
Large Pied Wagtail	—	—	—	—	13.6	13.6	9.0	—	9.0	—	—	—

Table 12

Different families of Beetle prey in the stomachs of 7 species of birds affecting agriculture

Species of birds	Cicindelidae	Carabidae	Dytiscidae	Gyrindae	Staphylinidae	Silphidae	Coccinellidae	Dermestidae	Bostrychidae	Cleridae	Cantharidae	Buprestidae
Pond Heron	—	—	10	2	—	—	—	—	—	—	—	—
Indian Roller	—	7	2	—	—	—	—	—	—	2	—	2
Small Green Bee-eater	3	—	—	—	1	—	—	2	—	1	2	—
Black Drongo	5	7	—	1	—	—	—	—	—	—	1	4
Common Myna	1	2	—	—	3	—	—	—	—	—	—	2
Whiteheaded Babbler	6	11	—	—	1	—	1	1	—	—	—	1
Large Pied Wagtail	3	5-6	1-2	4-5	1-2	1-2	—	—	—	1-2	—	—

Frequency of prey in 30-33 samples of stomach contents of each species

Species of birds	Elateridae	Tenebrionidae	Meloidae	Bruchidae	Chrysomelidae	Cerambyscidae	Lucanidae	Scarabaeidae	Hydrophylidae	Cassidinidae	Melolonthidae	Curculionidae
Pond Heron	1	1	—	—	—	—	—	1	5	—	—	—
Indian* Roller	—	—	2	2	10	2	—	10	—	—	5	9
Small Green Bee-eater	4	—	—	1	5	2	—	5	—	5	1	—
Black Drongo	2	6	—	—	8	—	1	—	—	—	—	1
Common Myna	1	4	—	—	8	—	1	14	—	—	—	1
Whiteheaded Babbler	5	15	—	—	12	5	—	3	—	—	—	5
Large Pied* Wagtail	7	9-10	5-6	—	—	3	—	—	—	—	—	7

*Made up to 30

TABLE 13

DIFFERENT FAMILIES OF BEETLE PREY IN THE STOMACHS OF 7 SPECIES OF BIRDS AFFECTING AGRICULTURE ARRANGED IN THEIR ORDER OF IMPORTANCE TO THE PREDATOR

Species of bird (Predator)	Order of importance of prey				
	(1)	(2)	(3)	(4)	(5)
Pond Heron	Dytiscidae	Hydrophilidae	Gyrinidae	Tenebrionidae/ Elateridae/ Scarabaeidae	
Indian Roller	Scarabaeidae/ Chrysomelidae	Curculionidae	Carabidae	Melalonthidae	
Small Green Bee-eater	Cassidinidae/ Chrysomelidae/ Scarabaeidae	Elateridae	Tenebrionidae	Cicindelidae	
Black Drongo	Chrysomelidae	Carabidae	Tenebrionidae	Cicindelidae	Buprestidae
Common Myna	Scarabaeidae	Chrysomelidae	Tenebrionidae	Staphylinidae	Buprestidae
Whiteheaded Babbler	Tenebrionidae	Chrysomelidae	Cicindelidae	Curculion/Elateridae/ Cerambycidae	
Large Pied Wagtail	Tenebrionidae	Curculion/Elateridae	Carabidae	Meloidae	

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OBSERVATIONS ON THE FOOD AND FEEDING HABITS OF BAYA WEAVER *PLOCEUS PHILIPPINUS*

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INTRODUCTION

Baya Weaver (Family : Ploceidae) is a resident and locally migratory bird and has a wide distribution in India (Sálim Ali 1972). The food of the adult Baya weaver *Ploceus philippinus* comprises of grass and weed seeds (Gramineae), cereal grains (Rice, Jowar, Bajra etc.), insects (grasshoppers, beetles, moths, caterpillars and spiders) and flower nectar wherever available. Nestlings are fed mainly on caterpillars, moths, grasshoppers, spiders and triturated tender paddy grains (Sálim Ali and Ripley 1974). Studies on stomach content of Baya *Ploceus philippinus* by Mukherjee and Saha (1974) revealed that in the non-breeding adult collected in October and dissected, the food comprised mostly of Rice grains together with 2 or 3 stone chips and in a few cases insects (samples of Jassids, Hemipterous nymphs and Lepidopterous larvae) were also associated with rice grains. Further investigations were taken up by the Scheme for studies on Biology and Control of Bird pests, Rajendranagar, (Hyderabad, A.P.) to study the food habit and feeding behaviour of Baya Weaver *Ploceus philippinus*. The period of investigation was one year, i.e., July 1975 to June 1976, which included also one breeding season of Baya i.e., from June to October 1975.

MATERIALS AND METHODS

Field studies on food and feeding habits :

The feeding of Baya Weaver on sorghum was observed in the experimental fields of Scheme for studies on Biology and Control of Bird pests, Andhra Pradesh Agricultural University, Rajendranagar, during Kharif and Rabi 1975-76. A plot of 20·00 Cents was taken up in Kharif and a plot of 17·25 Cents was taken up in Rabi 1975-76 for observation on sorghum crop. For observation on rice crop, cultivators' fields were selected for studying the feeding habits of Baya, and in addition, observations on feeding habits and population counts were done in the plots, sized 50 Cents (½ acre) in Kharif, and 100 Cents (1 acre) in Rabi 1975-76 at Agriculture College Farm, Rajendranagar. There was no bird scaring in the sorghum and paddy plots under observation. The observations on the food and feeding habits of the bird on the two crops mentioned, were done with the help of field binoculars during the peak visit hours of the birds, i.e. 6 to 10 a.m. and 3 to 6 p.m. Exact number of hours spent in the field observation was from 6 a.m. to 12 Noon and 3 p.m. to 7 p.m. in the evening. Thus, totally ten hours, i.e. six hours in the morning session and four hours in the evening session were devoted to bird pests observation in the paddy and sorghum fields. Out of the hours devoted, peak hours of the bird's visit were 7 hours, i.e. 6 to 10 a.m. in the morning and 3 to 6 p.m. in the evening.

Lab studies on gut contents :

Adult Baya Weaver birds for gut content studies were obtained from the fields by shooting with air gun or trapping with a mist net. Immediately they were dissected and gut contents examined and identified. Totally, fifty five (55) adult Bayas were dissected for gut content studies during the period under report. The monthwise details are furnished in Table II. As can be seen from this Table, during the months November 1975 to January 1976, the Baya Weaver were not found in Rajendranagar area and its vicinity as the crops were in sowing to vegetative phase and there was probably local migration of this bird.

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Lab studies on food preference :

Bayas (8 nos.) were maintained in a wire mesh cage. They were offered a known quantity of paddy, sorghum and bajra grains every morning and the quantity consumed was found out next morning by weighing the left overs of these grains. The food intake study data per day per bird for the 12 months of study period is presented in Table I.

Assessment of quantity of Sorghum and Paddy grains consumed in the field by Bayas :

Based on the results of laboratory studies on food preference of sorghum and paddy by Bayas, the quantity of these grains likely to be consumed by the population of these birds visiting the two crops on one hectare area is calculated and presented (Tables III & IV).

For arriving at an estimate of the density of population of Bayas visiting the two crops per hectare area, the actual counts of the birds visiting the crop in the specified plots (Cols. 3 and 4 of Tables III & IV) are taken as the basis. The average quantity of sorghum and paddy grains consumed per day per bird, during the period under report, as per laboratory studies on food preference (Table I), i.e. 0·76 gms and 5·50 gms respectively, is taken as the basis for arriving at the amount of sorghum and paddy grains actually consumed in the field.

RESULTS AND DISCUSSION

Sorghum :

Baya Weaver in groups of 2 to 7 and sometimes singly visited the sorghum crop in milky and early dough grain stage and damaged the earheads by picking the individual grains from spikelets, leaving the glumes intact. Sometimes the glumes too were picked up along with grains. The number of sorghum grains picked up was 5 to 10 in a single sitting under unscared conditions. As per the population counts the number of Bayas visiting the sorghum crop was on an average 11 per day in Kharif and 65 per day in Rabi 1975-76 (Table III, Cols. 3 & 4). The density of population of this bird per hectare calculated on this basis comes to 138 and 942 in Kharif and Rabi 1975-76 respectively.

Rice :

In Paddy nurseries the Baya Weaver birds fed on the exposed germinated and ungerminated seeds and pulled out the just sprouted seedlings before they established. At the vegetative phase of the crop, Bayas cut the young leaf blades into strips for use in the construction of nests. After the emergence of the panicles, Baya Weaver in groups of 2 to 7 visited the Paddy fields and by perching at the base of the panicle of each tiller, fed on the individual grains rendering the panicles chaffy. Similar method to that followed for sorghum was adopted in paddy also for bird counts. During Kharif, the bird visitants were 35, 45 and 60 in the milky stage (13 days), dough stage (15 days) and in hard grain stage (18 days) respectively on an average per day per hectare. During Rabi, the bird visitants were 33, 40 and 50 in milky stage (12 days), dough stage (14 days) and hard grain stage (16 days) respectively on an average per day per hectare. Thus totally the number of Baya visitants during Kharif came to 140 and in Rabi the Baya visitants were 123.

Gut content studies :

Out of 55 birds examined for gut contents, 27 had only rice grains as gut content and 5

TABLE I

STATEMENT SHOWING THE FOOD PREFERENCE OF BAYA WEAVER *Ploceus philippinus* FOR 12 MONTHS (1975-76)

Month & Year		Average consumption per day per bird		
		Paddy	Bajra	Sorghum
July 1975	..	5.34 gms	0.93 gms	—
August 1975	..	5.30 gms	1.20 gms	—
September 1975	..	5.98 gms	1.96 gms	—
October 1975	..	4.89 gms	1.15 gms	—
November 1975	..	5.70 gms	0.68 gms	—
December 1975	..	7.65 gms	0.80 gms	—
January 1976	..	6.25 gms	0.84 gms	—
February 1976	..	7.00 gms	1.37 gms	0.68 gms
March 1976	..	4.94 gms	—	0.84 gms
April 1976	..	3.40 gms	—	—
May 1976	..	4.60 gms	—	—
June 1976	..	4.97 gms	—	—
Total	..	66.02 gms	8.93 gms	1.52 gms
Average	..	5.50 gms	1.11 gms	0.76 gms

In the above Table—denotes nil consumption by the Baya Weaver.

TABLE II

STATEMENT SHOWING THE NUMBER OF ADULT BAYAS DISSECTED DURING 1975-76

Month & Year			No. of Bayas dissected
July 1975	..	..	6
August 1975	..	..	5
September 1975	..	..	8
October 1975	..	..	8
November 1975	..	..	—
December 1975	..	..	—
January 1976	..	..	—
February 1976	..	..	1
March 1976	..	..	7
April 1976	..	..	6
May 1976	..	..	9
June 1976	..	..	5
	Total	..	55

Table III

Population of Baya Weaver *Ploceus philippinus* visiting plots of observation trial of sorghum (Var. CSH. 5) at Agricultural College Farm, Rajendranagar observed during Kharif and Rabi 1975-76 and estimation of Sorghum grains consumed per hectare of crop area

Crop season	Susceptible Stages of the crop	Baya population in obs. plot		Total No. of Bayas visiting per hectare area of the crop (Calculated) (Average per day)	Quantity of sorghum grains consumed per hectare/per day on the basis of Lab. studies on food preference (*)	Total No. of days of milky and early dough stage of grains during the crop season	Total quantity of grains consumed during susceptible stages of crop
		Plot size (in Cents)	Total No. of Bayas visiting from 6 to 10 a.m. and 3 to 6 p.m. (Average per day)				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kharif 1975-76	Milky and early dough stage of grain	20.00	11	138	105 gms	12	1.260 Kgs
Rabi 1975-76	-do-	17.25	65	942	716 gms	10	7.160 Kgs
Total (Kharif + Rabi)		37.25	76	1080	821 gms	22	8.420 Kgs

(*) The quantity of sorghum grains consumed, on an average per day, per Baya, as per lab. studies comes to 0.76 gms (Table I).

TABLE IV

POPULATION OF BAYA WEAVER *Ploceus philippinus* VISITING THE OBSERVATIONAL FIELDS OF PADDY (Var. Tella Hamsa) AT AGRICULTURAL COLLEGE FARM, RAJENDRANAGAR OBSERVED DURING KHARIF AND RABI 1975-76 AND ESTIMATION OF PADDY GRAINS CONSUMED PER HECTARE OF CROP AREA

Crop season	Susceptible Stages of the Crop	Baya population in obs. plot		Total No. of Bayas visiting per hectare area of the crop (calculated) (Average per day)	Quantity of paddy grains consumed per hectare/per day on the basis of the lab. studies on food preference (*)	Total No. of days of each susceptible stage of the crop	Total quantity of grains consumed during susceptible stage of crop
		Plot size (in Cents)	Total No. of Bayas visiting from 6 to 10 a.m. and 3 to 6 p.m. (Average per day)				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kharif 1975-76	(i) Milky stage ..	50	7	35	192.50 gms	13	2.502 Kgs
	(ii) Dough stage ..	50	9	45	247.50 gms	15	3.712 Kgs
	(iii) Hard grain stage	50	12	60	330.00 gms	18	5.940 Kgs
		Total ..	28	140	770.00 gms	46	12.154 Kgs
Rabi 1975-76	(i) Milky stage ..	100	13	33	181.50 gms	12	2.178 Kgs
	(ii) Dough stage ..	100	16	40	220.00 gms	14	3.080 Kgs
	(iii) Hard grain stage	100	20	50	275.00 gms	16	4.400 Kgs
		Total ..	49	123	676.50 gms	42	9.658 Kgs
Grand Total (Kharif + Rabi)	..		77	263	1446.50 gms or 1.446 Kgs	88	21.812 Kgs

(*) The quantity of Paddy grains consumed on an average per day, per Baya, as per lab. studies, comes to 5.50 gms (Table I).

had only sorghum grains. In the remaining 23 Baya Weaver, 3 were found with sorghum and rice grains, weed seeds, mollusc shells (*Helix* sp.), sand particles and insect parts (grasshopper complete, insect sclerites and legs) and the remaining 20 had grains of sorghum, ragi, bajra, anthers and pollen grains of plants (belonging to Gramineae family) and triturated mass of tender paddy leaves and rice grains.

Food preference studies :

Out of the 3 types of food grains namely paddy, sorghum and bajra, offered throughout the year, Bayas preferred only paddy grains all through the year and consumed this in large quantities along with bajra. Bajra grains were shown second preference and taken along with paddy grains during July 1975 to February 1976. Sorghum grains were shown the last preference and taken only during February and March 1976.

Assessment of quantity of Sorghum and Paddy grains consumed by Bayas :

As per laboratory studies (Table I), Bayas consumed on an average 0.76 gms sorghum grains per day per bird. The Bayas in the field, fed on sorghum earheads, in the milky and early dough stage of grains, which lasted for 12 days in Kharif and 10 days in Rabi 1975-76. For Kharif, the amount of grains consumed in one hectare area by 138 birds comes to 1.260 kgs and in Rabi in the same area consumption by 942 birds comes to 7.160 kgs as presented in Table III (Cols. 5 and 8).

The Bayas consumed on an average 5.50 gms of Paddy grains per day per bird as per the laboratory studies conducted for studying the food preference (Table I). The Bayas feed on all stages of paddy crop, i.e. milky, dough and hard grain stages in the field in both the Kharif and Rabi seasons, and the details of bird visitants and their consumption is presented in Table IV. The total number of bird visitants in all the susceptible stages of paddy crop in Kharif comes to 140 and the likely consumption by these birds per hectare comes to 12.154 kgs and in Rabi 123 Baya visitant's likely consumption is 9.658 kgs paddy grains (Table IV, Cols. 5 and 8).

The quantities of sorghum and paddy grains, estimated to be consumed by Bayas in the field, over the area of a hectare of a crop, calculated on the basis of laboratory studies on food preference, though theoretical, have been attempted with a view to get a rough idea of grains damaged by birds for food. Under natural conditions, the actual intake of the quantity of sorghum and paddy grains in the fields might be more than in the captive conditions of a laboratory cage for the obvious reasons like need for more food intake for more calories of energy to meet the flight movements (over large areas) and other metabolic activities.

A comparison of the quantities of sorghum and rice grains consumed by the Bayas reveals that this bird prefers paddy to sorghum grains and this is in confirmity with the results obtained under laboratory studies of food preference (Table I).

SUMMARY

On sorghum crop, no damage was done by Baya Weaver in the seed germinating stage or vegetative phase. Only the ripening grains (milky and early dough stages) suffered from Baya Weaver damage when these grains were picked individually for food from the earheads, leaving the glumes intact. The assessment of quantity of sorghum grains consumed by Bayas in the milky and early dough stages of the grains in an area of a hectare for the two agricultural seasons of a year comes to 8.420 kgs.

On Rice crop, Baya Weaver bird acted as a pest in the germinated and pre-germinated seeds, in the early vegetative phase and in the maturing stages of grain. The damage in these

stages comprised of feeding on germinated and pre-germinated seeds and pulling out the just sprouted seedlings before they established, cutting the leaves into fine strips for nest construction and feeding on the individual ripening grains (milky to hard grain), respectively. In Kharif and Rabi seasons the total consumption by the Bayas in all the stages of the paddy crop is estimated to be 21.812 kgs in an area of a hectare. Bayas preferred paddy over sorghum grains.

The gut content studies revealed that in 49.09% of the Baya Weaver population dissected and studied, the stomach had only rice grains. In 9.09% population, only sorghum grains were found, 5.45% population had sorghum and rice grains, weed seeds, mollusc shells (*Helix* sp.), sand particles and insect parts and in the remaining 36.36% population, the stomach contained grains of sorghum, ragi and bajra, pollen grains and anthers of Gramineae family and triturated mass of tender leaves of paddy and rice grains.

Thus, in 94.55% Baya population dissected, the stomach contained only grains of rice, sorghum, ragi and bajra ; plant parts namely, pollen grains, anthers, triturated mass of tender leaves of paddy and rice grains. In remaining 5.45% Baya population, though the stomach contained grasshoppers and other insect parts, it was not the sole content and was mixed with sorghum and rice grains, weed seeds and sand particles. The gut content analyses results lead us to the inference that Baya Weaver adult, in this area is mostly grainivorous in food habit.

Amongst paddy, sorghum and bajra grains offered in cage (in the laboratory) Bayas preferred paddy followed by bajra and sorghum, the average quantity consumed per day per bird being 5.50 gms, 1.11 gms and 0.76 gms respectively.

ACKNOWLEDGEMENT

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ABNORMAL NESTS OF THE BAYA WEAVER BIRD *PLOCEUS PHILIPPINUS* (LINN.)

V. C. AMBEDKAR[1]

(*With a plate and a text-figure*)

INTRODUCTION

This report deals with a field study of the Baya Weaver Bird *Ploceus philippinus philippinus* (Linnaeus) (Family Ploceidae) made in the Kumaon terai, Dist. Naini Tal, Uttar Pradesh, during its breeding season—July, August—in 1974. While searching for a good breeding colony of the Finn's Baya *Ploceus megarhynchus* in the Kumaon terai for a filming operation, I came across a very unusual breeding colony of the baya on a lofty tree (*Mitragyna parviflora*) where nearly half the nests were of abnormal forms besides the usual retort-shaped nests. The colony was exceptional and the largest in the area I studied. The breeding colony was so unusual that it merited investigation for the abnormalities of nest structure, its causes, and other related problems. There seems to be no previous study that has focused attention on such abnormal nests, except stray notes that had appeared in various journals (Jesse 1897 ; Prater 1932 ; Ali and Ambedkar 1956 ; Ambedkar 1964 ; Crook 1964). The observations presented here, were made from 8 August to 24 August, 1974.

During the breeding season—May to September—the male establishes his territory and constructs his retort shaped nests on a tree (of various species, Davis 1974), usually over a pool of water. Afterwards these nests are accepted by females. It is a polygamous species, and the male acquires females successively in a short period. Moreover he maintains two or three half-built nests (Helmet stage) for accommodating unmated females. The nests are conspicuous and the birds are noisy while constructing their nests. Though granivorous, this bird also consumes a large amount of insects. Details of breeding biology of the baya are given elsewhere (Ali 1931 ; Ali and Ambedkar 1956, 1957 ; Ambedkar 1958, 1964 ; Crook 1960 ; Mathew 1976).

STUDY AREA

The observations were carried out in the premises of the Pantnagar Agriculture University, Pantnagar (lat. 29°N, long. 79° 30′E, Altitude 243.84 m, a.s.l.), Dist. Naini Tal. The particular colony I watched was located by the side of a road, surrounded by open grassland. This open grassland becomes swampy during the monsoon and afterwards the ground became squelchy wet for a considerable number of days. Various species of grasses grow profusely. When the study was undertaken, the height of the grass was as much as eight feet or more, at the end of July. To breeding birds, this provided easy nesting material and shelter at hand. Interestingly, there was no water below the tree.

ECOLOGY OF THE COLONY

The tree *Mitragyna parviflora* on which the colony was situated was nearly fifty feet high. Beside the tree, as well as on the opposite side

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of the road, Sheesham *Dalbergia sissoo* trees were present, but the baya selected this particular tree for nesting purpose. In other places, in the Kumaon terai, as well as in and around Pantnagar area, the baya very often used Sheesham trees. The reason for selecting *Mitragyna parviflora* in this area was not understood.

An interesting feature of the colony was that the nests were built only on the lower branches from six to thirty feet above the ground in all directions, the rest of the upper branches remaining vacant. The baya was seen to prefer lower branches for nesting in other sites too. There were about 150 males, and more than 200 females in the colony, and the densest aggregations of nests so far noted.

It was observed that about a dozen Indian Whitebacked Vultures *Gyps bengalensis* (Gmelin) were roosting every evening on the top-most bare branches of the tree. The vultures used to arrive one after another for roosting well before the sunset, when the baya were still active, building nests, singing chorus songs, courting unmated females, and feeding the young.

A pair of Spotted Munia *Lonchura punctulata* (Linnaeus) was constructing nest on the upper branch of the tree at the height of 40 feet from the ground above the nests of the baya and did not show any visible interest in the nests of the weaver birds. (cf. the behaviour of Whitethroated Munia *Lonchura malabarica*, see Ali 1931.)

About 5-6 house swifts *Apus affinis* were circling and wheeling around the tree from morning to evening. I could not find any particular aspect of their association, but Kirkpatrick (1950) has reported the roosting of the house swift in old disused baya nests. He further stated that the house swift found it difficult to enter the nests through the entrance tube.

On 14th August I observed a Crimsonbreasted Barbet *Megalaima haemacephala* on an upper branch, sitting and calling.

A pair of house crow *Corvus splendens* visited and lingered round about the colony from morning to evening probably looking for chances for robbing eggs and young.

NESTS

For the first time, I recognised three types of nests built by the baya weaver bird, though the basic essential features were the same. The following description is based on field observations made at Pantnagar.

Type—I :	Normal single chambered retort-shaped nest.
Type—II :	Abnormal nest having one, two or more nest chambers one below the first in linear succession.
Type—III :	Composite nest of dozen nests laterally fused into each other to form a big mass.

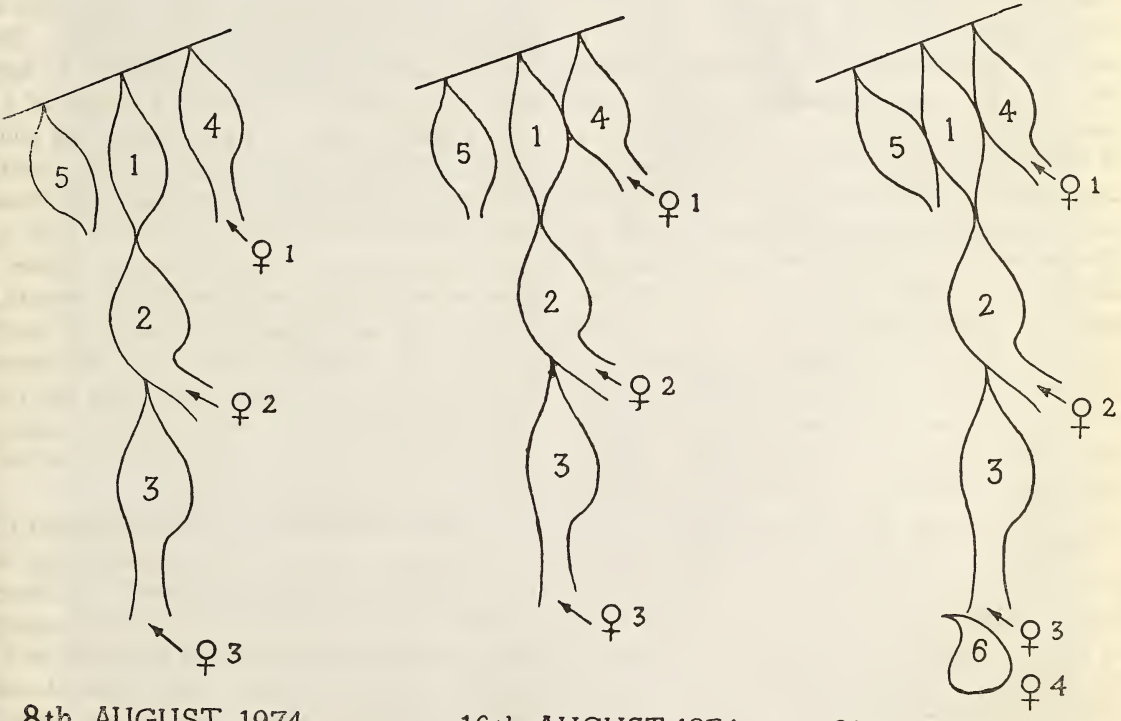
(1) **Normal single chambered retort-shaped nest :** The nest was suspended from a twig and it had an elongated entrance tube projecting vertically downwards. Stages in nest construction (1) wad, (2) initial ring or transverse loop, (3) helmet or bell, (4) the completed egg chamber, (5) the completed nest with a long entrance tube hanging downwards, described in detail by various workers (Jerdon 1863 ; Hume and Oates 1890 ; Dewar 1909 ; Ali 1931 ; Ali and Ambedkar 1956, 1957 ; Ambedkar 1958, 1964 ; Crook 1960, 1964 ; Davis 1971).

(2) **Abnormal multichambered linear nest :** It has been observed here and at Pune (Maharashtra) that the male always sealed off his first completed nest and started to use the entrance tube of the first nest at the point of suspension for his second nest. The latter was duly occupied by a female (same ?) and laid her clutch of eggs. But she left the nest, either of her own accord (see below) or

was probably preyed upon by an enemy. Since the male baya did not incubate the eggs he again sealed off the nest leaving behind the eggs in the egg chamber (Ali and Ambedkar 1956). In this fashion he built successive chambers one below the other. Here the main purpose of the nest, i.e. to rear the young, failed even after the eggs were laid in the nest.

During the study period, I observed a six storeyed nest in the colony. On 9th August the entire structure toppled down for some reason. It was examined by Dr. Sálim Ali and myself by cutting open each and every chamber. In the first or upper most chamber one addled egg was found. The next two chambers were empty, the fourth contained three fresh eggs and the fifth held two addled eggs, while the sixth or the last chamber was empty. There was no inter-connection between the chambers, each nest being a separate unit. The total length of the entire structure was 160 cms (5 feet 3 inches). From the blackish appearance of the fibres of the first and second chamber, it appeared to me that the male started to build the nest well before the other males; and he was successful in getting females one after another who used to lay their eggs in the egg-chambers.

I have also observed a six-storeyed nest in Pune in 1956. The length of this entire structure was 115 cms and it weighed 156 gms. Jesse (1897) described a nest of seven chambers from Lucknow and the last three chambers in this nest contained 3, 3 and 2 eggs respectively. Baker (1934) writes, sometimes a second nest is attached to the bottom of the first by another pair of birds; in such cases the junction of the two nests being hollow and allowing



8th AUGUST, 1974

16th AUGUST, 1974

21st AUGUST, 1974

Fig. 1 Stages of abnormal nests construction.

free passage to the pair of tenants of the 'Upper flat'. I did not come across such situation as 'hollow and free passage', but on the contrary each unit was observed as a separate and independent unit.

However, it has been observed that a male built more than one nest one below the other, but without obstructing the passage so that the females could continue to use their respective nests independently. There were only four nests of this type in the entire colony.

I give below some interesting field observations made on individual birds marked with colour rings, which throw light on the behaviour and constructions of abnormal nests.

MALE NO. 17

On the morning of 8th August, I observed this male having three nests, one below the other. The first nest (No. 1) was sealed off, and the second nest was constructed below (No. 2). This was occupied by a female who was probably incubating eggs. From the flank of the entrance tube of the second nest, the male constructed his third nest (No. 3), which was also occupied by the another female. Both the females were incubating their eggs, entering and leaving the nests freely. All the while the male was giving more attention to No. 2 and No. 3 by adding grass fibres to the outer surfaces of the nests. Occasionally he paid visits to Nest No. 1 and added some long strips and gave more support to the suspension point. There were two nests at the sides of these and their owners were not noticed.

Although I was watching and studying the colony daily, I was surprised to see the change in the position of nests on 16th August 9.30 a.m. on the very next day after a snake invasion on the colony. The male pulled Nest No. 4 towards the three-chambered nest, and by adding grass strips, Nest No. 4 was actually fused with Nest No. 1. Between 20th August and 23rd August he added one more nest (No. 5), an old derelict nest from left and gave more support to the long swinging structure.

Furthermore he constructed a new nest (No. 6) upto the helmet stage, and got a new female. Copulation was observed on 23rd August morning. Thus the Male No. 17 had four mates and owned six nests, out of which one nest was inoperative.

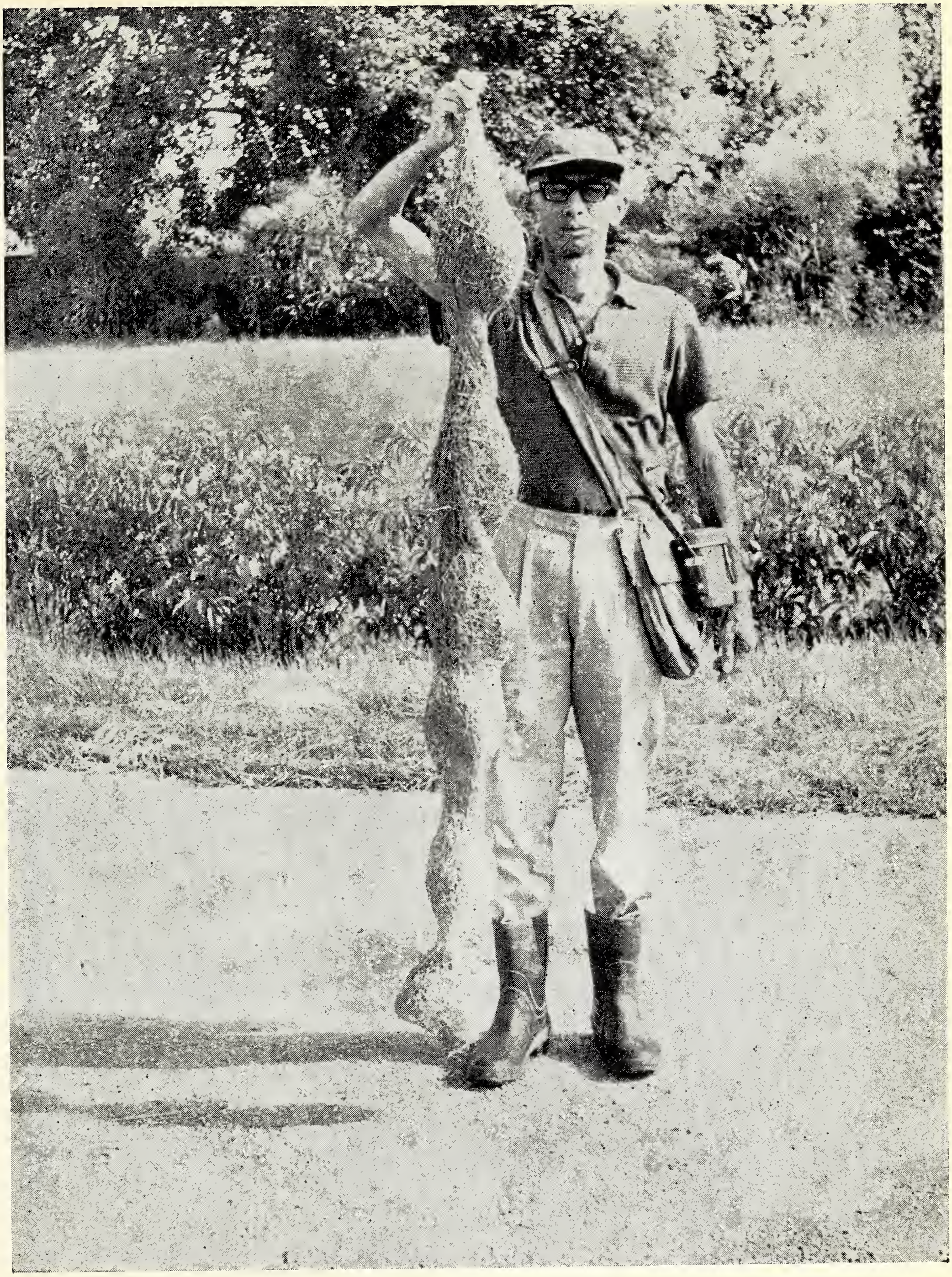
MALE NO. 30

This male had two nests side by side. In the course of maintenance activities, he pulled his nests together and fastened them together by adding and interweaving the grass strips, leaving the entrance tubes free to allow the female's movements.

(3) **Composite nest :** This was a particularly interesting part of the colony. On a thick branch of the tree and about 15 feet above the ground, I observed a cluster of 11 nests actually fused with each other, the connecting walls being linked together with strands of fibres. In this composite unit nest, only three nests were occupied and active at the time of observation period. One nest was at 'helmet' stage where the male was courting an unmated female. She was repeatedly visiting the nest, showing her interest in the nest. Whenever she left the nest, the owner went after her for long distances trying to bring her back again. This courtship chase was sustained for not less than two hours in the morning.

This entire structure of 11 nests belonged to at least three males who were maintaining it by adding fresh strands of grasses. At times the male took loose ends of fibres left hanging from an adjoining nest and tied it into his nest. On this occasion, if the owner returned and found the culprit, a severe fight took place, occasionally both males pulling the fibre from opposite ends—a sort of a tug-of-war.

Ambedkar: Abnormal nests of Baya Weaver



Author with 6-storeyed Baya nest. Kumaon terai, August 1974.
(Photo: *Sálim Ali*)

In the colony, there were, 95 normal single retort shaped nests, 60 nests of two chambers, 19 nests of three chambers, 8 nests of four chambers, 1 nest of five chambers, 1 nest of six chambers and 1 composite nest of 11 nests respectively. In all, the colony consisted of 185 nests including normal and abnormal nests, or there were 326 egg-chambers, either empty or with eggs and young, on 22nd August, the day before I left the Pantnagar area. Besides these nests, 55 separate, ' helmet ' stage nests were ready for accommodating prospective unmated females. The birds were busy, from morning to evening, in constructing new nests, unmated females were constantly visiting the colony and the nests and the males were courting these females. The well-settled females were either incubating the eggs or feeding their young. The chorus song of the male birds could be heard from a considerable distance.

PREDATION BY SNAKE ON THE COLONY

During the course of the study, I observed the behaviour of a snake during its actual act of predation on the weaver bird colony. The impact of predation on the colony was severe.

On 12th August, at 6 p.m. while I was approaching the colony, I did not find the familiar joyous chorus song of nesting birds, displaying of the males and the liveliness of the colony. On the contrary, the birds of both sexes, were sitting nervously on the grass, around the tree and on the power lines, producing scolding call-notes *chit-chit-chit* etc. Occasionally one or two males or females were making attempts to fly towards their nests half-heartedly. A house crow was jumping nervously from branch to branch, producing his raucous call-notes, and a pair of common mongoose *Herpestes edwardsi* was looking at the tree from the ground. With the naked eyes I could not see anything on the tree, and so I picked up my binoculars and started to scan each and every branch, thinking something must be wrong in the colony. After searching for nearly 20 minutes I spotted a very large black snake nearly 7 feet long on a branch about fifteen feet above the ground, crawling slowly towards the nests. As he moved forward the house crow made a bold attempt, and pulled his tail downwards. Thereupon the snake hurled itself from the branch into the thick undergrowth about ten feet away and disappeared. This was at 6.50 p.m. It was on the tree for at least half an hour.

The next two days, I did not see the snake and the weaver birds were very active till 7.00 p.m.

When I started to watch the colony, on 15th August at 5.30 p.m. everything was all right. At about 6 p.m. most probably the same snake climbed the tree, and started to search the nests one after another. It was very active moving swiftly from branch to branch thrusting its head into normal and abnormal types of nests, as well as nests of the 'helmet' stages. Within a short time it examined about 50 nests and swallowed what it got from the nests. The process of swallowing could be seen clearly through my binoculars. In one nest, after thrusting its head through the entrance tube, its neck region bulged out, indicating that it probably swallowed a nest-trapped female. The house crow was harassing the snake all the time. Finally the snake jumped into the grass underneath and disappeared.

Probably the snake was not satiated and went down only to avoid the crow. After about 10 minutes it again climbed the tree, and without giving the least attention to the birds, and the molestation from a pair of the house crows, it started to search the remaining nearly 100 nests. By this time about 12-15 people stopped on the road to witness the act of the snake. It was very active and ruthless during its second assault. The day light grew more and more dim, but through the binoculars I saw markings on the body and it was a rat snake *Ptyas mu-*

cosus. The people were shouting, but the snake did not give up. The snake did not visit the composite nest or that branch of the tree, I considered this was very significant. It could also not reach the lowest 3rd and 4th egg chambers of the abnormal nests, although it made attempts to reach it. It stopped at about 7 p.m. descended from the tree and quickly hide itself in the undergrowth.

DISCUSSION

Lack (1954) states that 'colonial nesting is possible only for species which are comparatively safe from nest predators, which otherwise would be attracted to the spot'. The snake *Ptyas mucosus* who was probably living under the tree, was apparently preying regularly on the colony. It was also possible that its predatory activities was keeping pace with the laying and hatching of the baya's eggs, thereby clearing the entire colony at regular intervals. This was actually observed on 12th and 15th August. It appears, therefore, that the site chosen by the initial pairs was detrimental to the colony in course of time. There are records of attack by snakes on the weaver bird colonies from Africa (Skead 1947 ; Pitman 1958, 1962 ; Elgood and Ward 1963 ; Collias and Collias 1970, 1971 ; Maclean 1973). In India, Barnes (1887) observed a brown tree snake (*Boiga gokool*) which devoured nestlings from the baya nest. Similarly Ambedkar (1964) reported seeing a snake (*Xenochrophis piscator*) attempting to enter a baya nest overhanging a well, but at the last moment it fell into the well. These observations suggest that in the tropics snakes are important predators at nests. Further Ambedkar (Ali & Ambedkar 1956) reported that the nocturnal tree mouse, *Vendeluria oleracea* may destroy a brood of the Baya and establish its own nest within.

Although, the house crow *Corvus splendens* is considered a confirmed egg-stealer in India (Ali 1956), the behaviour and association of the crow pair with the present baya breeding colony was probably beneficial. The crow gave the first alarm call as soon as the rat-snake came out from its hiding place in the evening. Moreover, as soon as the snake climbed the tree, both the crows, made a successful attack on it, at least on 12th August, and drove it back.

The observed colony was the largest with the densest congregation of both males and females and was fully packed to its capacity. As soon as the eggs and, in some cases, females, were devoured by the rat-snake, the male baya, being a polygonous species, was obliged to start his second nest upon the previous structure. Thereby his nests came one below the other—the abnormal nests. Sometimes he built his third nest starting from the flank of the nest tube of the second nest (Male No. 17), leaving both the females to do their domestic duties. On the very next morning of the snake attack, i.e. 16th August, Male No. 17 pulled his 4th nest towards the first one, and both the nests were joined together with fresh grass-strips, suggesting that he was re-enforcing the entire nest structure.

It appears that the abnormal nests have survival value to some extent. As the length of the nest structure increased, the snake found it more and more difficult to approach the nest contents of the third and fourth chamber of the hanging nests. During its attack on the colony it did not visit the big composite structure of eleven nests, probably the irregular mass of nests deflected its attention.

This suggests that the eggs and nestlings from the third or fourth chambers, and the composite nest had more chances to survive. Further research work on this problem would be rewarding.

Acknowledgements

I am indebted to Dr. Sálim Ali for taking active part in the investigation of the problem. His constructive criticism during the final preparation of this report is gratefully acknowledged.

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BREEDING BIOLOGY OF THE BLACK DRONGO

E. A. A. Shukkur and K. J. Joseph[1]

(*With twelve photographs in two plates and five text-figures*)

INTRODUCTION

The Black Drongo, *Dicrurus adsimilis macrocercus* Vieillot is a resident bird in Malabar, Kerala, India. Not much is known about its breeding biology. Ali and Ripley (1972) have recorded much information about the morphology, behaviour, food and breeding biology of the northern Indian race. The same authors (op. cit.) have given some information on the plumages of the juvenile and subadult stages of the southern Black Drongo.

There are very few other recent studies on the biology of this bird. The present paper is based on observations made on the biology and ecology of the Black Drongo in the Calicut University Campus from 1973 to 1976.

STUDY AREA

The Calicut University Campus is 227 ha. in area and falls in the narrow tract of land between the Western Ghats and the Arabian sea. The campus terrain is undulating with open grassy meadows, rocky promontories and ravines. Outcroppings of hard laterite rocks interspersed with gravelly and red loamy soil are common. Many species of grasshoppers and coleopterans are present here and form a large portion of the food of the Black Drongo. The characteristic cultivated plants of the study area are the jackfruit tree *Artocarpus integrifolia*, Cashew *Anacardium occidentale*, the Mango tree *Mangifera indica* and the coconut palm *Cocos nucifera*. Interspersed with these are clumps of Calycopteris *Calycopteris floribunda*. The ground cover consists mainly of the grasses *Apocopis mangalorensis* and *Setaria pallidae*. There are many paddy fields bordering the campus. The study area receives an average rainfall of 7 cm to 100 cm between the months of April and July and an annual rainfall of 300 cm.

METHODS OF STUDY

The Black Drongos were observed by Shukkur during the breeding seasons using a 10 × 50 prism binoculars. About 2500 hours were spent in the field and a total of 65 nests and 59 breeding pairs were observed in the four breeding seasons from 1973 to 1976. Each nest was visited every day noting the progress in building, egg laying, size and weight of the eggs, incubation, growth of nestlings, their development of plumage and general behaviour. The eggs and nestlings were weighed near the nests using a torsion balance with a precision of 0.1 gm. The temperature of the nestlings was measured by placing an ordinary thermometer under the wing for one minute. The brooding was observed continuously for 2 hours at 5 nest sites for a total of 162 hours for the entire study period.

To study plumage and moult, 100 birds were collected from points 20 to 50 kms away from the campus. Observations on the juvenile plumage were based also on thirty-five nestlings

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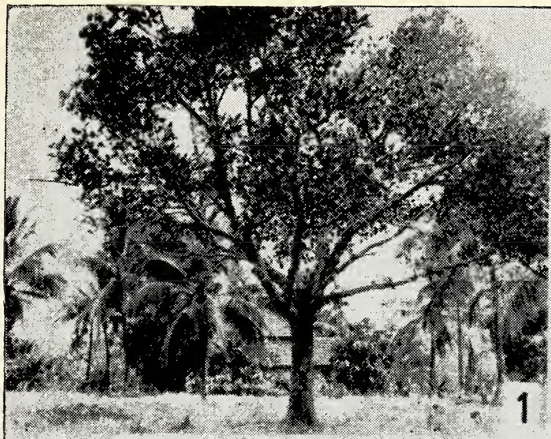
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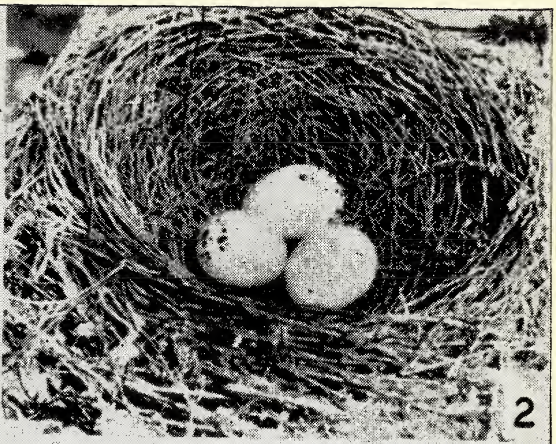
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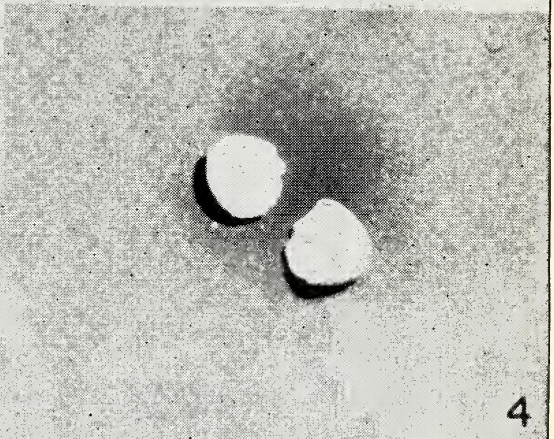
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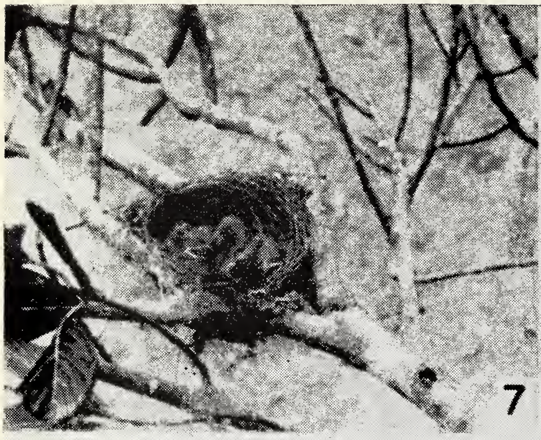
Photo. 1. A typical nesting tree (*Artocarpus integrifolia*) of the Black Drongo (Arrow indicates the location of the nest) ; Photo. 2. A nest of the Black Drongo with completed clutch ; Photo. 3. A breeding pair of the Black Drongo guarding the nest from their favourite perching post within the territory ; Photo. 4. Shells of a freshly hatched egg ; Photo. 5. Nestling Black Drongos in the 2nd and 3rd days of nest life ; Photo. 6. Nestling Black Drongos in the 5th and 6th days of nest life.



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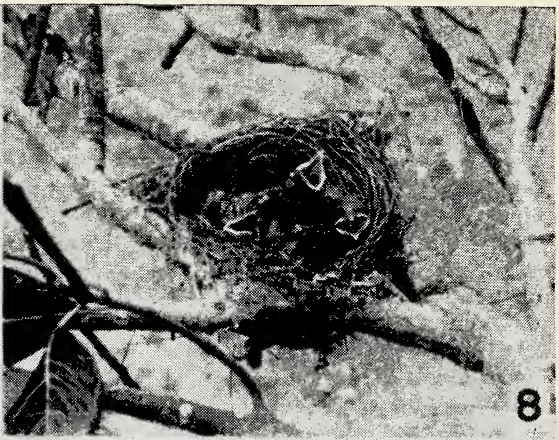

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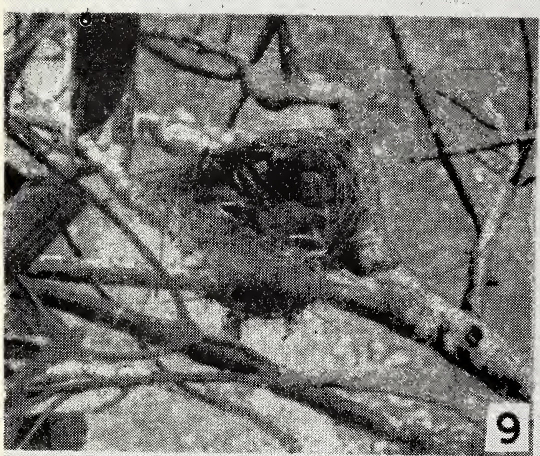

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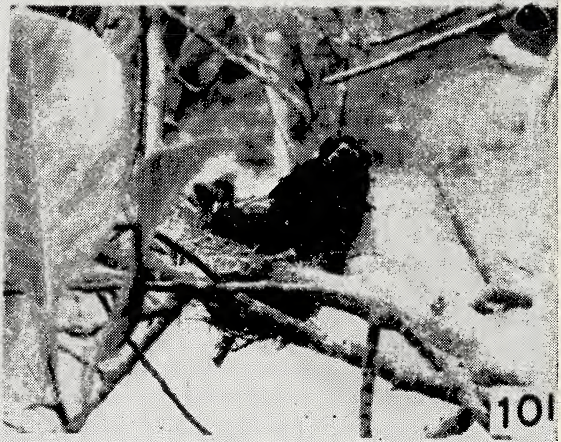

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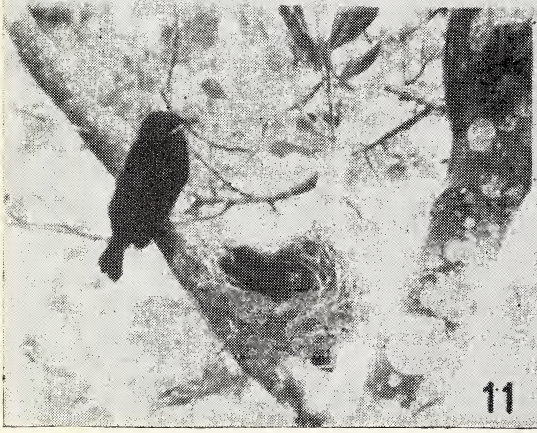

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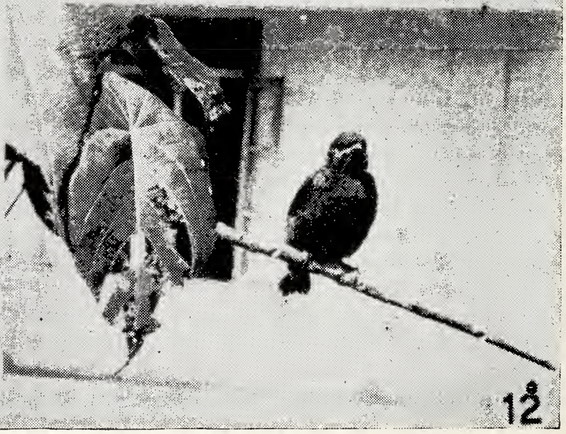

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Photo. 7. Nestling Black Drongos in the 8th and 9th days of nest life ; Photo. 8. 10th and 11th days of nest life ; Photo. 9. 12th and 13th days of nest life ; Photo. 10. 15th day of nest life ; Photo. 11. 16th day of nest life ; Photo. 12. Just fledged nestling on the 17th day.

ringed in the campus. Nestlings were ringed with the AB size (inner diameter 4 mm) aluminium ring of the Bombay Natural History Society and coloured plastic rings.

During the breeding season the female Black Drongo was identified at the time of egg laying based on the size, and depth of the fork of its tail which was slightly different from that of the male bird. Some deserted nests were taken to the laboratory, measured and dissected to identify the materials used in nest construction.

The breeding territory of the Black Drongo was marked as the area around the nest encompassed by the radial distance upto which the Jungle and/or House Crows (*Corvus macrorhynchos* and/or *C. splendens*) freely entered the home range. The mean radial distance was calculated by taking ten observations each at ten nest sites.

The abundance of insects during different months was estimated by making monthly counts at ten randomly selected sites of one sq. metre area each. Four such counts were made each month.

RESULTS

Status and general habits :

The Black Drongo is resident in the study area where it affects open fields, lawns and gardens around buildings. Ali (1953) recorded that this Drongo preferred gardens of jackfruit, cashew and coconut trees for breeding. Moreau (1935) studied its distribution in Africa and considered this to be a savannah species which now inhabits secondary forests. It is largely a solitary species hunting insects after locating them from perches on bushes, telegraph wires or on the cattle grazing in the campus. But when termites swarmed (Shukkur 1978; Mathew, personal communication) flocks of upto 25 birds fed together. Groups of upto 10 drongos feeding for long periods on mosquitoes emerging from drainage canals and septic tanks were observed repeatedly by the above-mentioned workers. It joined the foraging parties of the Whiteheaded Babbler (*Turdoides affinis*) and the Jungle Babbler (*T. striatus*). During the harvesting and ploughing operations in the paddy fields, it perched on elevated posts nearby to pounce on the insects flushed out. It feeds voraciously in the morning hours and hunts for insects attracted to electric lamps in twilight hours and as late as 2 to 4 hours after sunset and also ½ to 1 hour before sunrise.

The Black Drongo is very active during the early morning period singing and feeding alone or in pairs. In our study area duetting is most prominent in the morning hours in the pre-breeding months of February and March. Helversen and Wickler (1971) have described the details of the duet in the African race of *D. adsimilis*. The Black Drongo spends the mid-day quietly on shady trees.

Plumage and moult :

It was possible to differentiate the age groups of the Black Drongo on the basis of plumage. From observations of the marked young birds the diagnostic features of the birds in different stages of life were worked out and an outline of such features is given below :—

Juveniles or first year (3-12 months old) :

Feathers of the underparts of the body, undertail coverts, and underwing coverts are white-tipped. The rictal spot is larger and conspicuous. Colour of bill and legs is slaty black.

The second year bird (1-2 years old) :

Tips of the feathers of the undertail coverts alone white-tipped.

The adult (two years or more) :

Adult Black Drongo is glossy jet black in colour with deeply forked tail and compact body. The bare parts like the bill and legs slaty black in colour.

The Black Drongo moults its feathers during June/July to October. The flight feathers moult in an orderly fashion, i.e. the wing moult starts in June/July from the most proximal or the first primary and progresses in the ascendent order towards the tenth. Secondaries moult from July/August after the primary moult has progressed to the third quill. The secondary moult is less orderly. The 8th and 7th secondaries usually moult earlier than the remaining ones. The rectrices moult from central pair outwards and very symmetrically. The rectrix moult starts after the primaries have started moulting and is completed before the wing moult is completed.

Each primary greater covert, and uppertail covert moults along with the corresponding remex and rectrix. The secondary greater covert does not moult along with its secondary quill but either before or after it. The Black Drongo moults its body feathers from July to November.

BREEDING BIOLOGY

Breeding season :

During the period 1973 to 1976 we examined 65 nests. In the study area the Black Drongo breeds from April to June. The breeding season is defined here as the period from the date of the building of the first nest to the date of the fledging of the last chick. In the study area the Black Drongo started breeding after the first showers in April (Table 1 ; Figs. 1 & 3) and completed breeding in June before the start of the heavy monsoon.

The breeding season was so timed that the eggs and nestlings escaped the rigours of the severe summer and monsoon. The nestling period (Figs. 1 & 3) coincided with the time when the insect food was on the increase. The nestlings fledged when the insect food was available in plenty.

Breeding age and pair bond :

The Black Drongo appears to remain paired throughout at least one whole year as indicated by our close observations on a single pair where the male was marked. A male bird which fledged in 1973 bred for the first time at the age of 22 months. Judging from the age of birds on the basis of plumage it would appear that both male and female Black Drongos breed for the first time when they are about two years old.

Pair formation and selection of nesting sites :

From December onwards the second year and older birds start perching closer to each other and producing long, soft, chirping calls.

TABLE 1

BREEDING SEASON OF THE BLACK DRONGO IN THE STUDY AREA DURING 1973-1976

Years	1973	1974	1975	1976
Dates of the first 3 rains in the study area ..	April 19, 22 & 23	April 3, 4 & 8	April 12, 13 & 14	April 6, 7 & 14
Date when the building of the first nest started ..	April 28	April 10	April 14	April 17
Date when last nestling fledged	June 30	June 22	June 4	June 14

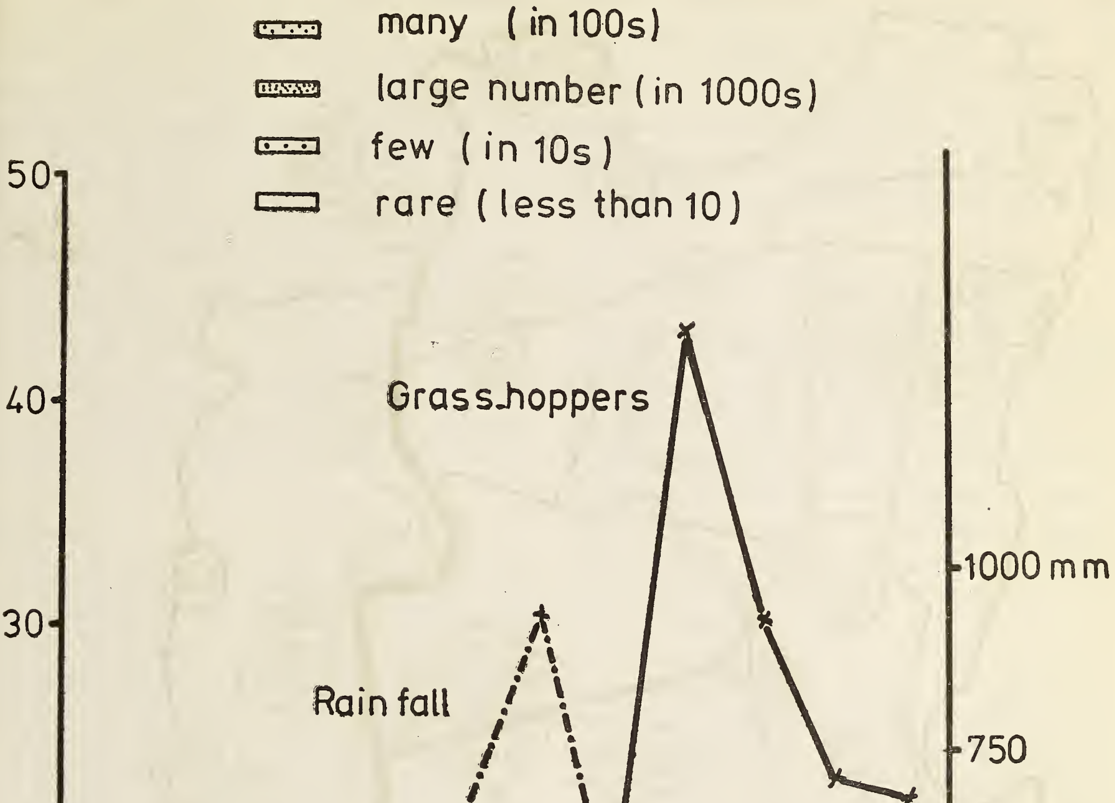

Fig. 1. Insect abundance during different months of the year compared with that of rainfall. Data pooled for four years and average taken. (Only three counts made during November, December and January.)

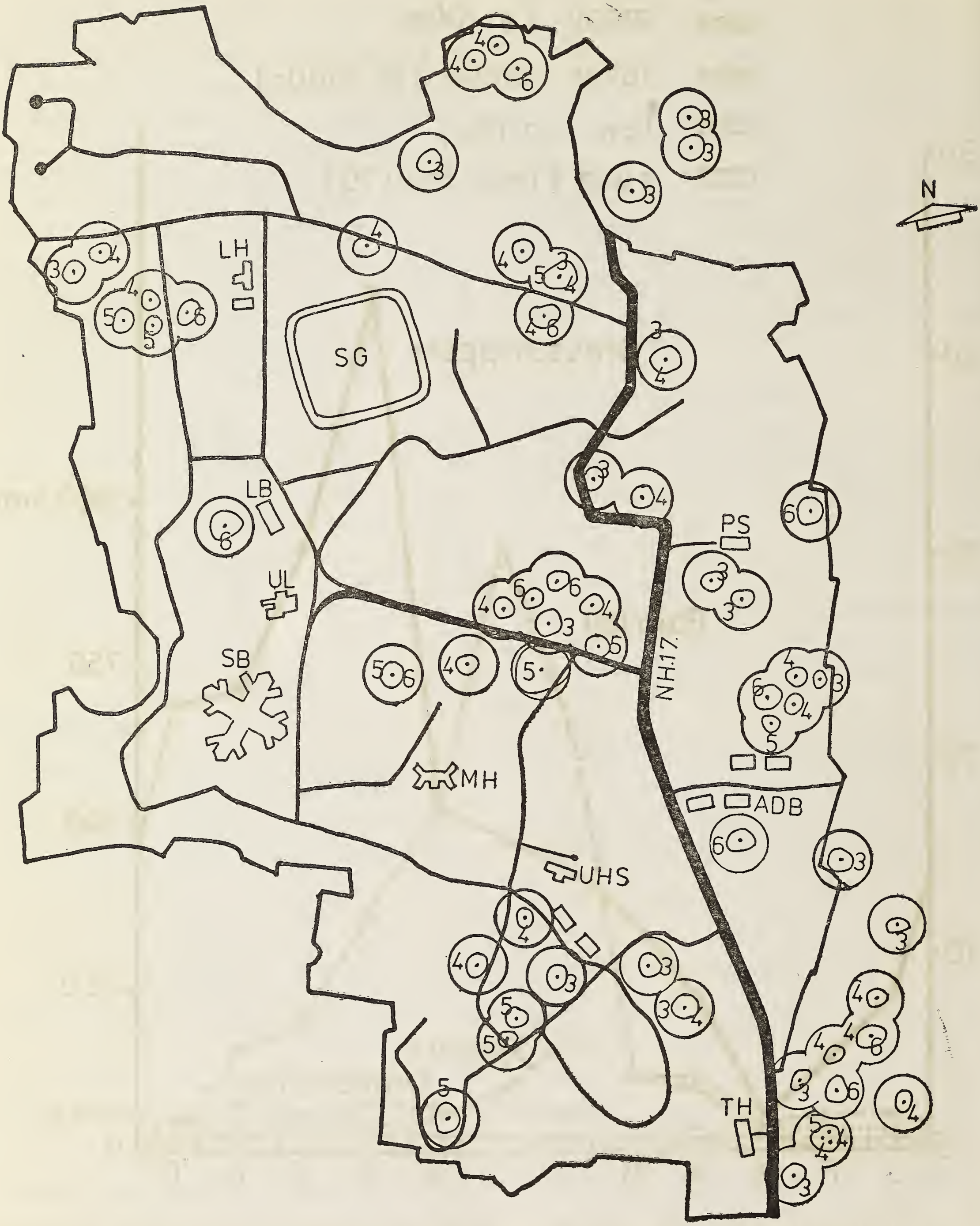

Fig. 2. Map of the study area with the nest sites 1973(3), 1974(4), 1975(5), 1976(6). Inner approximate circles :—Area encircled by favourite perching posts. Outer circles :—Area defended from House and Jungle crows (Mean radius 43.2 m). Scale 1 : 8,000. NH. 17. National Highway 17 and other important land marks (ADB, UL, SB, LB, UHS, TH, MH, LH, SG, PS).

This is one of the earliest signs of courtship. Such pairs indulge in duetting and vigorous pursuit flights. Von Helversen and Wickler (op. cit.) refer to the African Drongo duetting outside their breeding season also. The nest site seems to be selected between late February and early March. This is the time when the pair starts defending their territory. The nests are situated in forks of trees like Mango, Jackfruit and Cashew. Early in the courtship period the nesting birds could be seen hopping about on these forks tilting and turning their bodies to the sides, generally going through the motions of building a nest without any nesting material. This behaviour appears to be a type of vacuum activity.

Territory :

Once the nest site is selected the pair defends the surrounding area particularly against conspecific individuals. The territory is more vigorously defended after the commencement of incubation. The Jungle and the House Crows (*Corvus macrorhynchos* and *C. splendens*) and the Blackwinged Kite (*Elanus caeruleus*) are not allowed to enter the territory. The Southern Tree Pies (*Dendrocitta vagabunda*) and Orioles (*Oriolus* sp.) could move within the Black Drongo's territory but not on the nesting tree. The territory comprised an area of 0.3 to 1.2 ha. (Fig. 2) around the nesting tree. The nesting pair has a number of perching posts on tall trees around the nest. The topmost point on a very tall tree which gives a good view of the area around is usually the most favourite perching post of a nesting pair.

Courtship and copulation :

A nesting pair indulges in vigorous courtship activities. Such birds chase each other in flight and bring their bills and wings into contact as though in sham fight. In the course of this their wings get interlocked and the pair may fall to the ground. Courtship included many vocalisations with the pair singing duets or merely singing together. Only once was copulation observed ; a female which had perched on a branch slightly lowered the forepart of her body raising her tail ; the male which was nearby mounted her, tilted his tail and brought his cloacal opening close to that of the female.

Nest location and building :

For nesting purpose, the Black Drongo appears to prefer the grassy areas interspersed with trees, a feature which gives it a good view of the area around. The patches of grass provide grasshoppers, beetles, spiders and other arachnids, centipedes and worms in plenty which serve as prey for the Black Drongo. About a third of the campus area which does not satisfy this requirement is not used by the Black Drongo for nesting.

The nest of the Black Drongo is a thin bottomed cup situated in the fork of a tree. Small twigs, grass and fibres are pressed together and draped with cobwebs. The nests are built at points closer to the peripheral extremities of branches than to the tree trunk. Trees 5-30 m tall and standing singly in open areas are often preferred for nesting. Usually the nesting trees are situated 18 to 40 m away from any of the surrounding ones. The nest is located at heights of about 2.5 to 13 m from the ground. Forty per cent of the nests were located in the north-east portion of the trees, 23% each in the south-east and south-west and 14% in the north-west portions. The south-west portion bears the brunt of the strong winds characteristic of the month of June. The nest location on different trees in the study area is shown in Table 2.

The Black Drongo appears to prefer jackfruit trees for nesting. The closely planted cashew and densely foliaged mango trees which offer only limited view of the territory around seem to be less preferable as nesting sites to the

TABLE 2

TREES USED FOR NESTING IN THE STUDY AREA

Trees	No. of nests	Approximate No. of trees of the height 5-30 m
1. *Artocarpus integrifolia* ..	48	60
2. *Anacardium occidentale* ..	8	100
3. *Alstonia scholaris* ..	4	10
4. *Mangifera indica* ..	3	38
5. *Macaranga indica* ..	1	10
6. *Ficus* sp. ..	1	10

Black Drongo. On the other hand, the jackfruit trees have a more open type of leaf arrangement and the trees themselves are sufficiently removed from other trees offering a clear view of the territory.

A completed nest weighs about 15 gm and has a diameter of 9 cm and a cup depth of about 4 cm. The nest is built with fibres from the fronds of the coconut palm (23.5% by weight) twigs from the Gooseberry Tree *Phyllanthus emblica* (16.4% by weight) and the Triple-nerved Lizard foot *Scuropus quadrangularis*, and cobweb. All the materials used for nest building are available in the nesting area. The fibres from fronds of the Coconut palm provided the matrix. Ribs of the leaves of the Gooseberry Tree imparted rigidity. As is common in passerine nests, cobweb bound the building materials together and with the fork of the branch of the tree. In 26 cases observed it took 5 to 8 days to complete the nest, the average being 6 days. Both sexes take part in nest building. Building activity is faster from the third day onwards. In a day-long observation on the fourth day it was found that the material was brought to the nest at intervals of about 10 minutes in the morning and 20 minutes in the later half of the day. The builders took rest on the branches of the nesting tree or trees nearby for about 2 hours usually from 1200 hours to 1300 hours and from 1400 hours to 1500 hours. Each bird made about 35 trips to collect nest building material. A bird with new material does not approach its nest directly but waits nearby, watches around and then proceeds to the fork. In the early stages the builders sit in the fork and press the new material into the structure of the growing nest. Later on they may perch on the rim of the nest also. By pressing the body into the nest-cup and by moving from side to side the cup is shaped and widened. Egg-laying commences on the day after the completion of the nest.

Nest desertions :

Twenty-nine out of the 65 nests studied were deserted, five of these due to human interference. Year-wise break-up of data on nest desertion and the apparent or recorded reason for desertion are given in Table 3.

Re-nesting :

Five out of the 29 nesting pairs which deserted their nests built new nests on other trees in their home range. These 5 pairs were those disturbed while egg laying was in progress in their first nests. Drongos which deserted nests in the advanced stage of incubation did not renest.

Egg laying and incubation :

Sixty per cent of the eggs were laid within two weeks of the first rainfall (Fig. 3). The eggs are laid between 7 and 9 a.m. on consecutive days. When the female is in the nest for laying, the male watches from a favourite perch in the territory. As she comes out of the nest after laying, he flies towards her uttering a low pitched ' qui . . . qui ' call. The birds then perch on nearby branches, spread out their wings, fluff out their feathers and go for feeding.

Table 3

Year-wise Data of Nest Desertion During the Years 1973-76

Year		Total No. of nests built	Total No. of nests deserted	Apparent or recorded reason for desertion
1973	..	18	3	2 : human interference 1 : not known
1974	..	22	13	drought
1975	..	8	6	4 : drought 1 : human interference
1976	..	12	1	1 : human interference

Eggs were 2.4-2.7 cm long, 1.85-2.05 cm broad and weighed 4.8 to 5.8 g, i.e. 10 to 11.8% of the average body weight of 49 gms of an adult Black Drongo. The egg is elliptical and white with red spots all over. The spots are bigger at the broader end.

The clutch size was three in 46 cases and once 4 eggs. In two cases where one egg was broken after the completion of clutch, no further egg was laid.

The incubation period was 14 to 15 days. Both parents incubated and in two closely observed cases the male took a prominent role in incubation. The incubating birds rarely left their nests in the fore-noon. At noon the eggs were left unbrooded for about an hour. The nesting pair spent more time for feeding in the evening hours.

Eggs hatched asynchronously and the hatching period generally was between mid May and mid June (Fig. 3). A time lapse of 24 to 28 hours was observed between hatching of the first egg and of the last. Egg shell disposal was not observed.

The young and their development :

At hatching a nestling weighed 4 gm, 77.5% of the mean weight of the fresh egg. The nestling period varied from 16 to 20 days, though in most cases it was 16 to 17 days. The body weight of the nestlings increased steadily from the day of hatching until they were 12 days old. Thence the body weight remained more or less static and later in the prefledgling days, the weight decreased.

The newly hatched nestling is naked, ungainly and its eyes are not open. The body is flesh-coloured. The abdomen and ventral part of the lower mandible are paler. An egg-tooth is present. Conspicuous white rictal flanges line the margin of the mandibles towards the angle of the mouth. The lining of the mouth is yellowish-red. The beak is flesh-coloured and the tarsi shadow-black.

The nestlings call softly and direct their bills towards the source of food. The three-day old nestlings are able to raise their heads more efficiently to receive food and utter louder begging calls. The body coloration attains a darker tinge.

By the fourth day the feather follicles of the body tracts appear as black spots under the skin and by the fifth day they emerge out. The head is completely covered over with bristle-like outgrowths of feathers. The feathers of the rest of the body pterylae grow to pin stage by the seventh day and the remiges and rectrices protrude out.

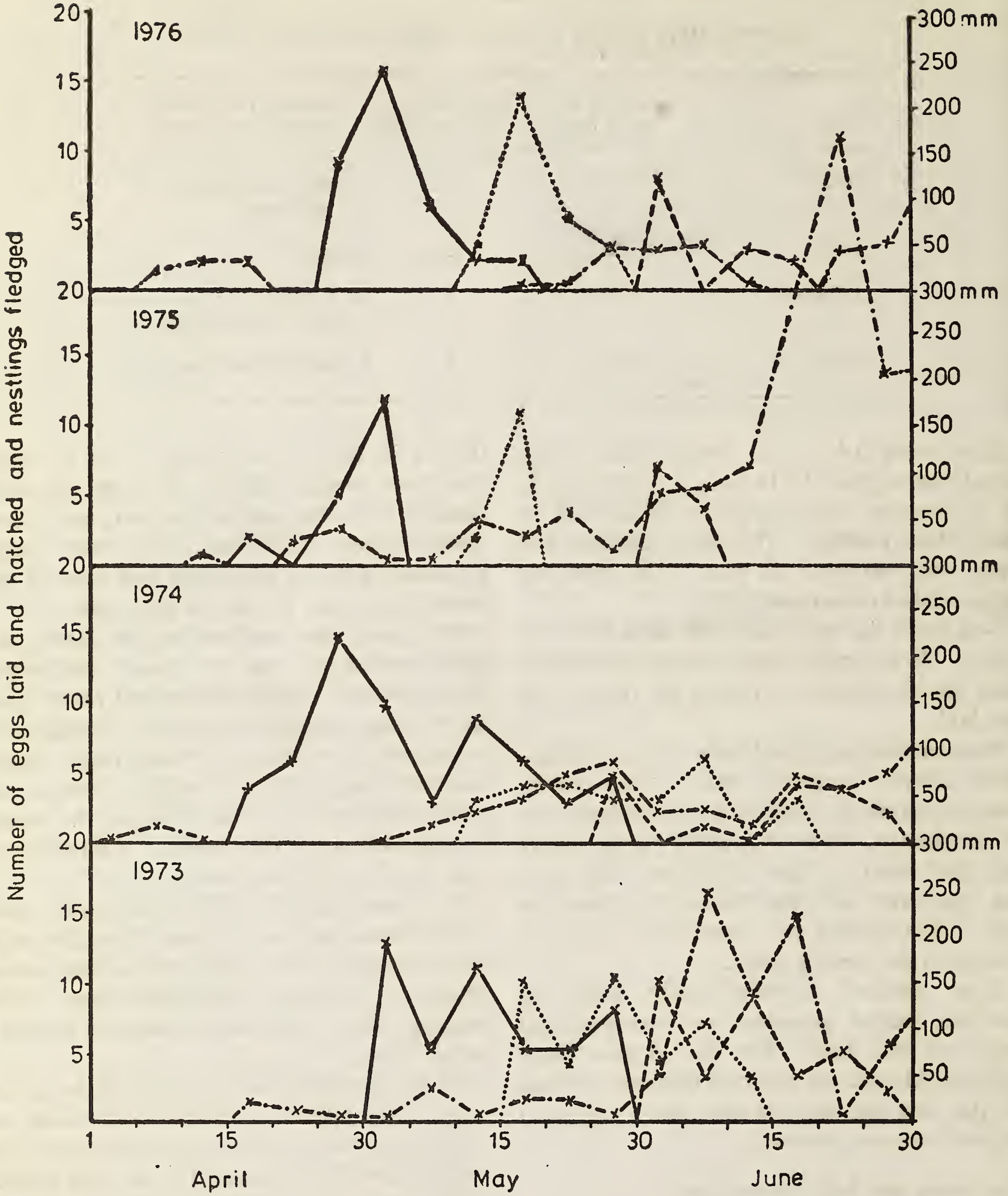

Fig. 3. Number of eggs laid (solid line), number of eggs hatched (dotted line) and number of nestlings fledged (dashed line) compared with the rainfall (dash and dot line) of the years 1973, 1974, 1975 and 1976, plotted in 5 day periods (Rainfall between 1 and 5 mm is plotted as 5 mm).

The eyes open by the eighth day and are coloured reddish-black. Now the nestlings start shivering movements of their wings and making louder calls than before. Their responses to stimuli like the calls of parents and vibrations of the tree are more prompt and strong. The beak turns more blackish; the gape changes to red and tarsi to black.

When 9 to 13 days of age, the feathers cover the body except in the underparts. The primaries, secondaries and rectrices grow longer. At this age all the rectrices are of equal length. From the ninth day onwards the rictal flanges grow shorter, becoming reduced towards the corner of the bill.

When two to three weeks old, the body and abdomen of the nestling are more proportionate in size. The underparts of the body are fully feathered. The feathers are glossy black on the upper part and tinged with white in the underparts. The nestlings flutter their wings and try to fly out of the nests. Normally the nestlings leave their nests on the 16th or 17th day though they are very weak fliers. If disturbed by man they leave their nests slightly earlier. The fledglings are fed by the parents.

Brooding and body temperature of the nestlings :

The temperature of the nestling Black Drongo varied from 30°C on the day of hatching to 42.5°C prior to fledging (Figure 5). The body temperature increased steadily from 30°C to 38-40°C in the first 10 days of nestling development. The nestlings maintain fairly constant body temperature from the fourth day onwards. The nestlings were brooded upto the fifth day of nest life. The time spent in brooding progressively decreased from a total of 58 minutes in 2 hours to 10 minutes in 2 hours, the duration of brooding in a single session varying from 1 to 6 minutes. Brooding was not observed after the fifth day.

Feeding of the nestlings :

The parents transfer whole food directly into the mouth of the nestlings. Early in the nestling period the chicks are given soft and small insects. Very often the food brought at one trip is sufficient to satisfy any one nestling only.

The fledgling :

Fledgling Black Drongos do not return to the nests once they leave it. The newly fledged birds do not have forked tails. They master flight slowly. The fledglings are guarded carefully and fed frequently by their parents for about a month, by which time they learn to fly fairly well. The tail develops the forks by the 20th day. There is a conspicuous white spot near the angle of the mouth. As late as 3 months after fledging, the young Black Drongos may beg for food, but the adults ignore them and try to drive them away. Nevertheless the fledglings usually remain close to the spots where they are reared for many more months. One ringed juvenile did so upto the 2nd year and nested on the same tree on which it was raised.

Breeding success :

The breeding success of the Black Drongo during the period 1973-1976 is summarised in Table 4. The timing and extent of rainfall in the breeding season appears to influence the extent of breeding success (Fig. 3). In the years 1974 and 1976 when the rainfall in the breeding months was uneven and very low, the breeding success was only 26% and 37% respectively (Fig. 3).

The influence of the first shower in April, in timing the breeding of the Black Drongo in the Calicut University Campus was clearly demonstrated in a histological study of the testes cycle of the species (Shukkur 1978). Examination of the sections of the testes of the bird every month (for one year) revealed that the spermatocytes and spermatozoa were present in the testes in one week after the first few showers.

The same author (1978) also examined in detail the role of the various factors like the availability of mates, suitable nesting sites, material for nests, food for the young and physical factors like temperature, moisture and rainfall on the nesting success of the Black Drongo. Mates, nesting sites and materials for nests were available throughout in all the years. Only the pattern and amount of rainfall in the breeding months varied. Accordingly

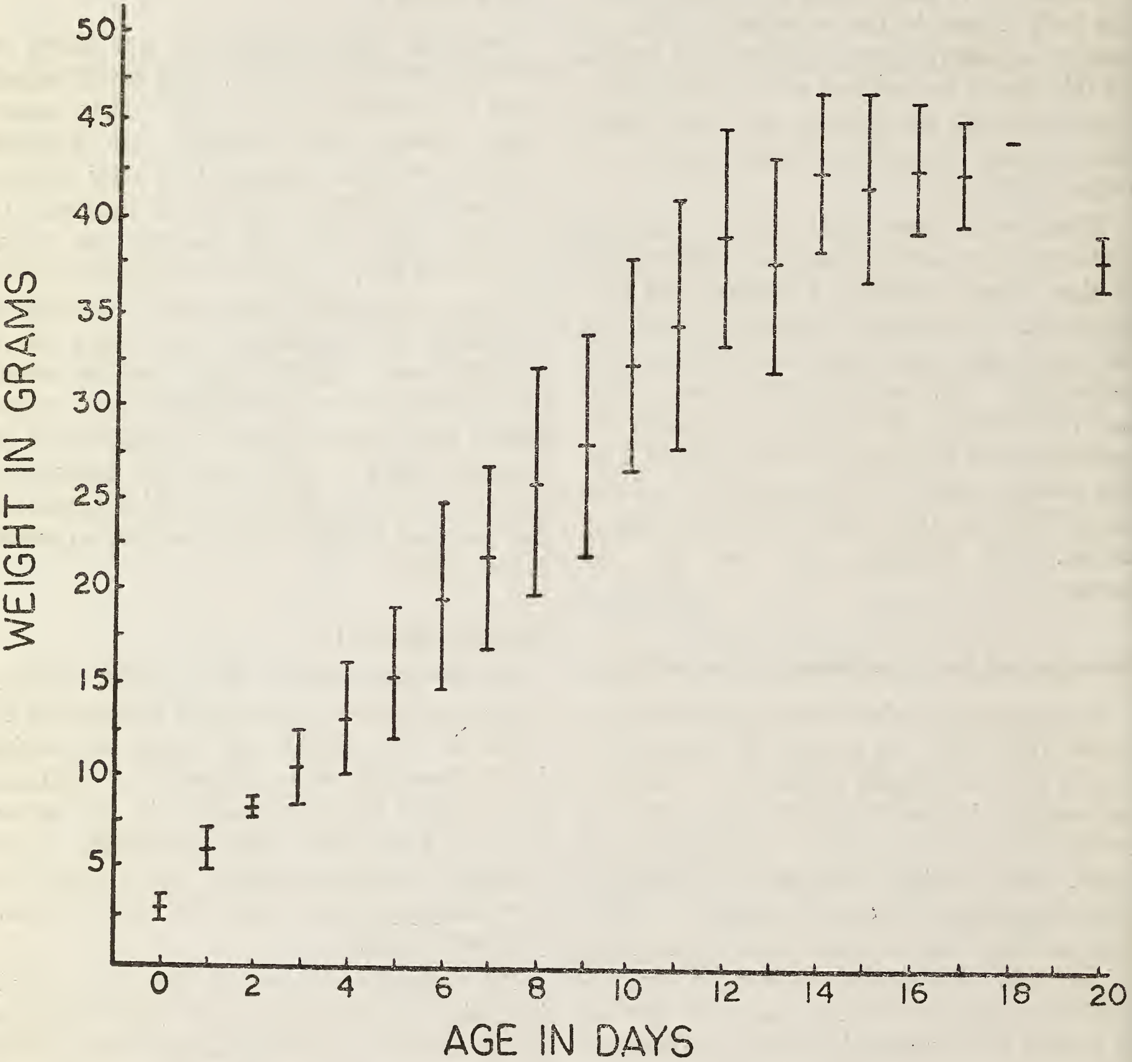

Fig. 4. Graph showing the daily weight increment of the nestling Black Drongos. Middle bar indicates mean ; Vertical bar indicates Standard deviation.

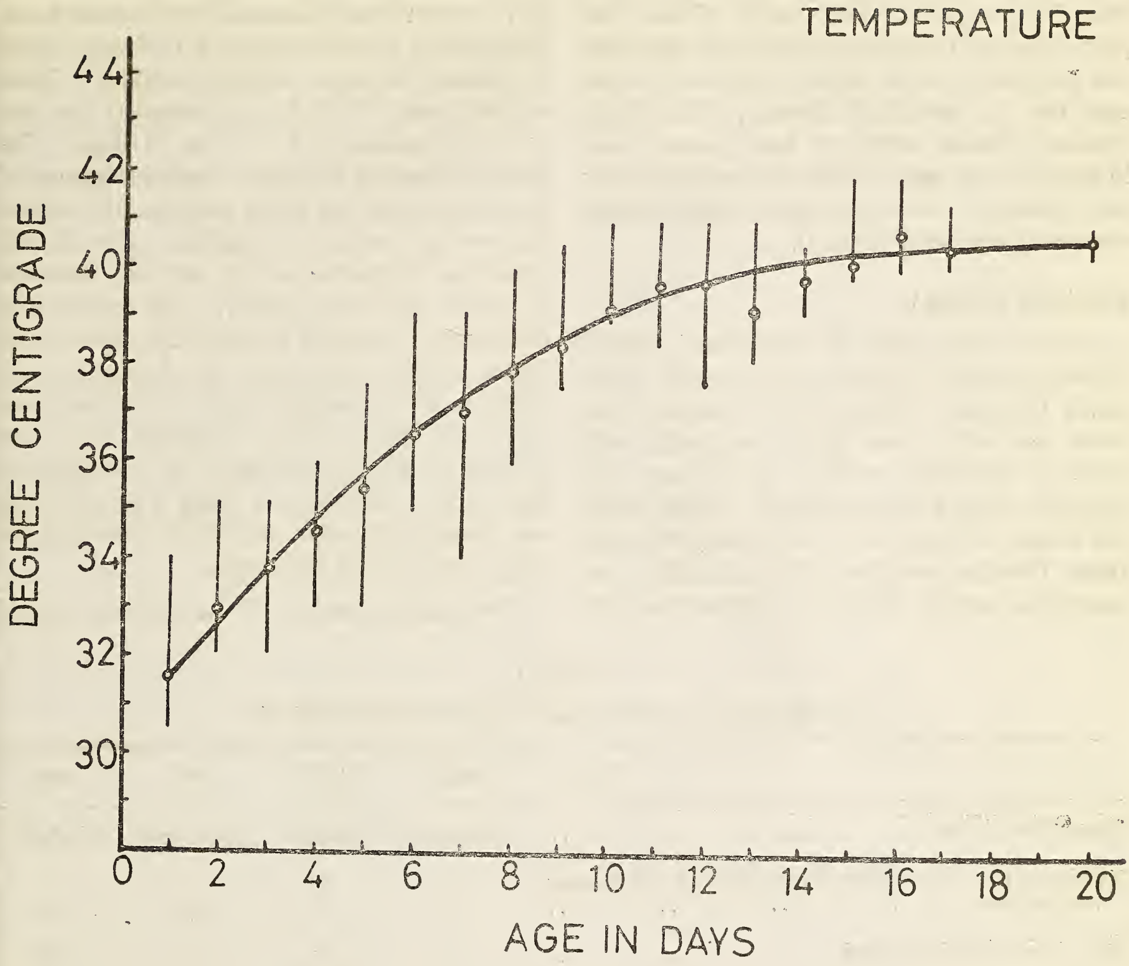

Fig. 5. Graph showing the temperature development of the nestling Black Drongos on the consecutive days of nest life. Circles indicate mean ; Vertical bars indicate range.

the percentage of the eggs hatched and nestlings fledged also varied (Fig. 3).

After the first rains of the season the grasses sprout and insects become abundant. This condition is maintained if there is normal rainfall during the following weeks (Fig. 1). If not, the grasses wither and insects decrease in numbers. This apparently results in food shortage for the nestlings and is one of the reasons for breeding failure.

The 65 nests examined during the four breeding seasons from 1973-1976 produced 72 fledglings. A pair of Black Drongos thus raised 1.11 fledglings on an average. Sixty-three per cent of the eggs hatched and 44% produced flying juveniles. Lack (1954) after studying the rate of survival of the eggs and young of nidicolous birds, concluded that in the passerine species with open nests the proportion of eggs and completed clutches which gave rise to flying young was rather under half varying from 22% to 59%. The results of our four years' study of the Black Drongo also suggested this proportion to be slightly under half of the eggs laid by the Black Drongo. The highly evolved defence behaviour and parental care in the Black Drongo may be an important factor contributing to the comparatively high breeding success of this bird (Table 4).

Proximity nesting :

In the study area the Redvented Bulbul *Pycnonotus cafer* nested in the territory of the Black Drongo. Gilliard (1958) recorded that birds like orioles and doves frequently built nests on the same trees as this drongo and enjoyed safety from crows and hawks which the Black Drongo drives off. Out of the 40 Black Drongo nests in which incubation was completed during 1973-1976, eighteen had the Redvented Bulbul's nests placed at distances of 1 to 10 m from them and on the same trees. The bulbuls started building 3 to 5 days after the Black Drongos started building. These bulbuls took 3 to 4 days to complete the nest and they incubated for 11 to 13 days. The bulbuls benefited from the vigorous defence of the territory by the Black Drongo with whom they seemed to have no conflicts. The Fantail flycatcher *Rhipidura aureola* was also observed to nest in the same manner. The bulbuls and flycatchers responded to the alarm calls of the Black Drongo and joined the drongos in the defence of the nesting area. In three cases when the Black Drongo deserted nests the bulbuls nesting close to them did not complete their nests. In one case when a drongo nest was destroyed by man, the bulbuls nesting on the same tree deserted their nests.

The nestling period of the Bulbuls was 12

TABLE 4

BREEDING SUCCESS OF THE BLACK DRONGO DURING 1973-76

Years	1973	1974	1975	1976
Date of first shower	19th April	3rd April	12th April	6th April
Number of rainy days during the one and half months after the first rain	24	6	15	9
No. of nests building started	19	23	11	12
No. of nests building completed	18	22+	8	12
No. of clutches started	16	21	8	12
No. of clutches completed	16	19	5	11
No. of nests incubation completed	15	10	5	10
Total No. of eggs laid	47	61	19	35
Total No. of eggs hatched	37	27	13	25
Total No. of nestlings fledged	32	16	11	13
Percentage (of total No. of eggs) producing fledglings .	67%	26%	58%	37%

+ 5 are re-nests.

to 15 days in 3 closely observed cases. The bulbul parents were not seen to collect any food from points close to the tree used for nesting by the drongos and bulbuls. More cases of such nesting associations have to be studied in greater detail for drawing more definite conclusions about the nesting relationships between these two species.

Discussion

These observations on the breeding biology of the Black Drongo *D. adsimilis*, carried out from 1973 to 1976 in the Calicut University campus cover four breeding seasons but the data are too meagre for any elaborate discussion.

The drongos began breeding after the early showers in April. On account of these rains, grasses sprout and insects become more abundant. The breeding drongos collect all their insect food from areas close to their nests. By the time the eggs hatch and the nestlings fledge, the monsoon will have increased in intensity ensuring a steady supply of food for weeks to come. Baker (1938), Skutch (1950) and Lack (1954 & 1968) have all observed how food for the young was the ultimate factor regulating the timing of breeding in birds.

Among the proximate factors operating on the individual bird, the first showers appeared to time the breeding season in the Black Drongo. Proper timing of the breeding activities is most important to the survival of the Black Drongo in our study area as this bird has a very short breeding season. The nestlings leave nests before the height of the monsoon. It is suspected that the Black Drongo remains paired throughout the year and in the same home range. This has to be proved by more observations.

In the study area the Black Drongo breeds only in grass growing tracts interspersed with tall trees. The Black Drongo has a territory of 0.3 to 1.2 ha. which is defended by both partners of a breeding pair. Howard (1914) observed that a large territory may help to regulate the size of the population in birds. There are only a few spots which have the combinations of conditions required by the Black Drongo for nesting in the study area. This may be one of the factors regulating its population here.

We have no evidence of predation and disease as factors causing mortality in the Black Drongo. Food is an important factor and is dependent on the distribution and quantity of rainfall.

The clutch size of three and the single brood raised by the Black Drongo seem to be very suitable for the local conditions. The heavy rainfall after June rules out the possibility of this drongo raising a second brood. According to Lack (1968) in species of birds in which parents feed their young the clutch size corresponds to the brood size from which the parents can on average raise more young. The average breeding success of the Black Drongos studied by us during 1973-1976 is 44% which is comparable to the average figure given for open nesting passerines by Lack (1954), and falls in its upper range. Could the Black Drongo raise a larger number of young by having a bigger clutch size? We doubt this since a larger clutch and brood may retard the growth rate of the individual nestlings and prolong their stay in the nest thus exposing them to heavy rains.

Lack (1954) thought that solitary nesting in birds helped to conceal the nest. The Black Drongo's nest is well concealed but its vigorous defence of territory and highly aggressive behaviour makes its nesting area very conspicuous. Perhaps since the Black Drongo is efficient in protecting its nest, concealment of nest is not very important to its breeding success.

The Redvented Bulbul which nested on the same tree as the Black Drongo avoided any conflict with the latter by not collecting any food from the areas close to the nest. The adult bulbul is an omnivore (Mathew unpublished). Its nest building, incubation and nestling periods are shorter than those of the drongo and this ensures uninterrupted protection by the proximity of the Black Drongo.

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ECOLOGY OF HOLE NESTING BIRDS

K. N. PANICKER[1]

INTRODUCTION

Literature on nidification of different species of birds is exhaustive, but information on comparative studies of species of different families having common ecological niches for breeding is meagre. A comparative study of different species using tree holes for breeding was undertaken to determine whether inter- and intraspecific competition for nest holes is a major factor in their breeding success.

The species studied are :

(1) *Psittacula krameri* (Scopoli) Roseringed Parakeet, (2) *Coracias benghalensis* (Linnaeus) Indian Roller, (3) *Megalaima haemacephala* (Muller) Crimsonbreasted Barbet, (4) *Acridotheres tristis* (Linnaeus) Common Myna, (5) *Sturnus pagodarum* (Gmelin) Brahminy Myna, (6) *Copsychus saularis* (Linnaeus) Magpie Robin, and (7) *Petronia xanthocollis* (Burton) Yellowthroated sparrow.

MATERIALS AND METHODS

The primary material for this study were the nests, nestlings and adults of the species of birds listed above. The nesting details were observed at the nesting sites. Routine observations were made almost every day during the breeding season using a 6 × 30 prismatic field binoculars. Among the same species, certain individual birds were recognised by constant observation of the pairs and their centres of activity. Nest construction, incubation period, and parental care were studied by sample observations of the nest from dawn to dusk. Food habits were studied by observation of the parent birds bringing food and confirmed with an analysis of the excreta of nestlings. The insect life of the study area was studied through local collections. Eggs and nestlings were weighed with a 'Salter' balance. To study individual pairs, the parent birds were caught with nylon mist nests and given a visible identification mark on the wings with enamel paint. Adults and fledglings were ringed with Bombay Natural History Society's rings and coloured aluminium rings prepared out of anodised aluminium strips.

STUDY AREA

Studies were initiated in a patch of land adjacent to a reserve forest called Ammundi at Thirumani village in North Arcot district, Tamil Nadu (12° 55′N., 78° 96′E.) situated at about 200 metres above MSL from January 1969 to December 1969. From March 1971 to August 1972 the study was continued in the Okhla Dam area Delhi (28° 38′ N., 77° 17′E.) at about 200 metres above MSL, and in the Delhi Zoological Gardens.

Thirumani : The selected area in the environs of Thirumani village was a private land about 250 metres away from the reserve forest of Ammundi, situated in North Arcot district of Tamil Nadu. It had the appearance of a tropical dry evergreen forest—with a canopy of small evergreen and deciduous trees with shrubby undergrowth. The study site covered approximately 2 hectares. The area was neglected and the trees maintained only for using the foliage as green manure in fields. There were 128 large trees in the selected area, the majority of them were *Albizzia lebbek.* Other species were *Tamarindus indica* and *Azadirachta indica.* Being soft wooded, *Albizzia lebbek* is favoured by hole nesters. The other trees in the area, *Tamarindus indica* and *Azadirachta indica* being comparatively hard woods were probably not attractive to hole-nesters. The main source of water was the river Palar flowing on the northern border. This river separated the study area from the Ammundi forest. During the study period, the river was dry. The main rainfall in this area is from the south-west monsoon during the months of June to October.

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The study area is bordered by agricultural lands cultivating paddy, ragi and sugarcane. Harvesting of the crops is in March (Ragi) and May (Paddy). The grains form a source of food supply for the breeding birds in the area. There are some peepal trees (*Ficus religiosa*) in the village nearby which provide food for a large number of frugivorous birds. Flowers and figs are available from early April onwards. The majority of parakeets and barbets nesting in this area were largely dependent on these peepal figs for feeding their young. Periodical collection of the insect fauna revealed species of the families Carabidae, Tenebrionidae, Cerambycidae, Acridiidae, Gryllidae. Species of the orders Odonata, Isoptera, Hemiptera and Hymenoptera were obtained during the study months from January to December.

Ecology of hole nesters

While all the hole nesting birds studied exhibit all the normal breeding activities such as establishment of territory and nesting site, pair formation, copulation, nest construction, laying of eggs, and care for the young, there is great diversity of pattern by which these phases are exhibited.

Breeding Season: The tree hole nesters have well marked breeding season. The breeding seasons of the species studied were given in table below.

The birds start their breeding activities before the onset of rainy season in both the study areas. Moreau (1950 a) has reported that tropical birds breed in relation to onset of rainy season and mentions the monsoon as the only apparent seasonal factor to which the breeding season of some species on Islands off the coast of East Africa can be related. Betts (1952) reported that in the hills of Southern India, parakeets and barbets breed early and this period corresponds with the blossoming of the principal nectar bearing trees and the ripening of the most important wild fruits like peepal figs and of crops, so that food for the young are easily available. The timing of the breeding season has many advantages as noticed by Betts (1952)

	Tamil Nadu	Delhi
Roseringed Parakeet	December to May	March to June
Crimsonbreasted Barbet	January to June	April to July
Indian Roller	April to July	May to August
Common Myna	May to September	May to September
Brahminy Myna	May to September	May to September
Yellowthroated Sparrow	April to June	May to August
Magpie Robin	April to July	June to September

in woodpeckers. Woodpeckers are the earliest to breed and there is no competition from other species as none nest in the cold season and secondly woodboring beetle larvae are in plenty during this period. Breeding season mainly is timed in such a way that the young can be reared at the time of maximum food supply (Thomson 1950). Lack (1950) has also shown that the availability of food as the most important factor in breeding. Late breeders like the roller and mynas have the advantage that the density of insects becomes high with the arrival of monsoon, which are the primary food supply for the young. It was observed during this study in Tamil Nadu area, that the ripening of ragi and paddy crops in surrounding fields and subsequent preparation of the field for the next crop resulting in flushes of insects and worms from February to July coincided with the breeding of the birds under study. Similarly the blossoming of Ficus and neem trees also started from early March which was advantageous to the frugivorous birds like parakeets and barbets for feeding the young.

Pair Formation :

During this study it was observed that the pair remains together throughout the breeding season. Mating was induced by a series of courtship display simple or elaborate. Parakeets rub their beaks and body for considerable time uttering low twittering notes and the female twisting herself into many postures, while mynas flutter around the vicinity of the general location of the selected nest hole often indulging in preening each others feathers. The rollers, however, have an elaborate courtship display rolling and flying high in the air and then diving headlong with harsh cries. Sexes were identified by watching the pairs at mating except in parakeets where the male has the rose ring around the neck.

A study was undertaken to find out whether the same partners were involved in the second brood. For this purpose, adults were caught in mist nets and given identification marks with coloured enamel paints. The marked pairs were observed until the second brood was formed. It was confirmed that the same birds were responsible for both broods.

All these species maintained a small territory around the nest hole, and the distance between two adjacent nests of the same species was as follows :

Parakeets ..	Less than 1 metre and more nests on the same tree.
Common Mynas ..	Approximately 3 metres.
Brahminy Mynas	Approximately 2 metres.
Barbets ..	Approximately 10 metres.

The hostility towards the same species varied in different degrees among the birds studied. The roller exhibited the maximum territorial aggressiveness while parakeets and Brahminy Mynas were the least aggressive.

Nest Construction : The birds studied included primary hole nesters and secondary hole nesters. The primary hole nesters are by definition species capable of excavating their own nests such as woodpeckers, barbets and parakeets as opposed to the secondary hole-nesters such as mynas and rollers which are dependent on natural holes or the abandoned nests of the primary builders for breeding. It was observed that parakeets which are early breeders, complete their breeding cycle in May, thus enabling the Common Myna and Indian Roller to occupy the same nest holes. Likewise Brahminy Mynas take over the nest holes of barbets. The breeding season of the two groups are so arranged that the secondary users invariably follow the primary nesters.

In choosing the site, in bringing the materials for building the nest, and in the construction of the nest, both males and females, take active part. The vegetation in the habitat not only provides nesting site and food but also barks, fibre, twigs, leaves etc. suitable for nest construction (Nickell 1958). The nests are built in such a way that they are concealed from nest predators. Proper selection of the site and protection of the nest ensures safe breeding for hole nesting species in general. Different materials are used to line nests. Common Myna and Brahminy Myna use mostly miscellaneous mass of feathers, straw, fine twigs, leaves and paper bits as nesting materials. Skin (slough) of snakes is also used for lining the nest. The materials are arranged in the form of a cup with a central depression for laying the egg. They accumulate material which weighs between 125 to 250 gm. No nest material was used by the roller in tree holes unlike Lamba's (1963) observation, the eggs being laid directly on the decayed debris of wood at the bottom of the hole. Similar instances were observed with Crimsonbreasted Barbets and Roseringed Parakeets.

Laying and clutch size: Egg laying started with completion of the nest in some cases and in some, while the nest was under construction. The variations of clutch sizes observed in different regions and of different birds are tabulated in Table 1.

Though the normal clutch size was 3 to 4, some variation was noticed in relation to the locality. All the hole nesters were found to lay their eggs in the morning hours, in both the study areas.

Lack states that climatic conditions and even a change of season influences the clutch size (Lack 1947, 1948 and Parkhurst & Lack 1946). The clutch size of the Common Myna from the south rarely exceeded four, whereas in Delhi it was up to six eggs. Clutches of the same size were recorded by Hume (1889) and Baker (1933). The average number of eggs in a clutch was 3.5 in the south and 4.6 in Delhi. The average number of eggs in a clutch of Brahminy Myna, was 3.3 in the south but in Delhi it increased to 3.5. Crimsonbreasted Barbet too showed a slight increase with an average of two in the south and 2.5 in Delhi. The roller showed

TABLE 1

VARIATION OF CLUTCH SIZES IN DIFFERENT REGIONS AND OF DIFFERENT BIRDS

Species	Locality	No. of Nests	Clutch Size		Standard deviation
			Range	Av.	
Common Myna	Thirumani	8	3-4	3.5	0.52
	Madras	3	3-4	3.3	0.59
	Delhi	3	4-6	4.6	1.17
Brahminy Myna	Thirumani	10	2-4	3.3	0.82
	Madras	—	—	—	—
	Delhi	9	3-4	3.5	0.61
Indian Roller	Thirumani	4	2-3	2.7	0.48
	Madras	—	—	—	—
	Delhi	2	2-3	2.5	0.70
Crimsonbreasted Barbet	Thirumani	3	2	2.0	—
	Madras	4	2-3	2.2	0.52
	Delhi	5	1-3	2.2	0.83

a different trend with an average of 2.7 eggs in the south and 2.5 in Delhi.

The eggs are rounded oval with a rough texture. Parakeets, barbets and rollers laid white coloured eggs. Common and Brahminy Mynas laid glossy blue and pale blue eggs, respectively. Lack (1958) has analysed the eggs of 151 species of the large Thrush family for the colour of the eggs and noted that colours of eggs tend to be associated with certain types of nesting site : species nesting in deep holes tend to have immaculate white eggs, those in shallower holes and crevices speckled white or immaculate blue eggs.

All the birds studied agree with Lack's conclusion except the Common Myna and the Brahminy Myna. Perhaps the breeding in holes is a later development in these species. The ability of mynas to construct nests outside of holes supports this assumption.

From the Table 2 giving the measurements of eggs of the roller and mynas, it is clear that the size of the egg is not constant for each clutch. This is perhaps due to the availability of food in the breeding area as noted by Preston (1953) which determines the size of the egg. The quality and the abundance of food in the locality influence the clutch size (Lack 1947). The heaviest egg of a Common Myna was 8 gm. and the lightest was 6 gm. In rollers, there is not much difference, the heaviest being 11 gm against the lightest 10 gm.

Incubation : The incubating bird spends varying amounts of time brooding the eggs. The roller spend two to seven hours in the nest incubating the eggs, in addition to overnight brooding. It sits for longer duration at a stretch than other species. The mynas had a different behaviour spending a maximum of ten minutes at a stretch brooding the eggs. However, one bird broods overnight. In the parakeet, the female does most of the incubation and the male relieves it at intervals. The barbet too, spend comparatively longer time brooding the eggs. During incubation the birds periodically turn the eggs as was evident from marked eggs.

Incubation Period: According to Nice (1954), incubation period is the elapsed time between the laying of the last egg in a clutch and the hatching of that egg. In general, eggs hatch in the order laid. The incubation period of the birds studied, are given below :—

Roseringed Parakeet ..	22 to 24 days (9 nests)
Indian Roller ..	18 days (3 nests)
Common Myna ..	12 to 16 days (8 nests)
Brahminy Myna ..	12 to 14 days (6 nests)
Crimsonbreasted Barbet ..	13 days (One clutch)

TABLE 2

EGG MEASUREMENTS IN MILLIMETRES

Species	Av. length	SD±	Range	Av. width	SD±	Range	Av. weight in gms.
Indian Roller ..	31.8	1.30	27-34	25.1	1.74	22-30	11.0
Common Myna ..	27.3	2.02	25-30	19.7	2.05	15-22	7.0
Brahminy Myna	25.3	0.94	24-27	24.3	0.94	23-26	6.2
Crimsonbreasted barbet ..	26.3	0.45	26-27	24.6	0.45	24-25	6.0

Young in the Nest : Observations were made on the young in the nest, their care, the nature of food fed to them, and feeding pattern. In all species studied, the newly hatched young were flesh coloured, devoid of feathers (except the Common Myna), and had their eyes closed. Both parents took part in feeding the young. As nestlings grew, the frequency of feeding became less. Lack (1968) observed 'rapid growth of the nestling is advantageous because the period of vulnerability to predators, is reduced'. A roller chick gains four to five gm weight within twenty four hours of hatching. By the third week, it will be fully fledged. Common Myna chick gains three to four gm weight in twenty-four hours after hatching and are fledged by the third week. As observed by Ricklefs (1973), the larger the species the slower is the rate of growth, for instance, the parakeets take a longer time to leave the nest. While nestlings of the rollers and mynas leave the nest when they are four to five weeks old, nestlings of the parakeet take six to seven weeks to leave the nest. It should be noted that the young of the rollers and mynas, are fed on a high protein diet as insects form the major portion of their food. The parakeets and the barbet feed the young mainly on grains and wild fruits respectively.

NEST SITE AND NEST COMPETITION

Early in the breeding season, the paired birds get busy with the selection of a nest site. Usually, a deep hole or hollow is selected for this purpose. In the southern study area, nests were found on trees like *Albizzia lebbek*, *Delonix regia*, *Enterolobium saman* and *Dalbergia sissoo*, whereas in Delhi the birds preferred *Tecoma indica*, *Morus alba* and *Azadirachta indica*. The order of preference of trees selected by different species in different localities, is presented in Table 3. *Albizzia lebbek* in the south and *Tecoma indica* in north, were favoured most. Both species of trees, are soft-wooded, which makes easy the excavating of a hole. Therefore, primary nest builders preferred these trees which were subsequently used by secondary hole nesters. In addition, secondary hole nesters were satisfied with any natural hole in trees.

The height at which the tree holes were found is given in Table 4 and the majority was between seven to ten metres from the ground level.

The lowest height in which the nest holes were found was three metres and the highest was thirteen metres from the ground for species except the barbet. The barbet's nests were seen from about 1.5 metres above the ground.

The parakeet preferred holes on the tree trunk while the barbet chose the underside of a dead branch. The parakeets, and the Common Myna occupy holes in the upper part of the trees, whereas the barbets and the Brahminy Myna used holes in the lower portion of the trees.

The entrance of the nest holes were usually oval and very rarely circular. The circumference of the opening of the nest holes from a sample in Thirumani is given in Table 5. It indicates that parakeet, Common Myna and the roller, being larger birds, occupied nest holes with a larger entrance while the barbet and the Brahminy Myna, being smaller birds, occupied holes with smaller entrance.

It is reasonable to assume that since the barbet's and the Brahminy Myna's nest hole openings were comparatively small, the roller and the Common Myna compete only with the parakeet for nest holes. The Brahminy Myna always prefers the barbet's hole and in the absence of such holes, they breed in deep holes often seen in the form of a cavity, well concealed within the branch or trunk with a small entrance and narrow communicating passage. These holes are not preferred by the common mynas and the roller. Clashes between them occurred

TABLE 3

ORDER OF PREFERENCE OF TREES IN DIFFERENT LOCALITIES OF DIFFERENT SPECIES

Species	Locality	Trees in order of preference	No. of Nests
Roseringed Parakeet	Thirumani	*Albizzia lebbek*	10
	Delhi	*Tecoma indica*	9
		Ficus benjamina	4
		Azadirachta indica	3
Crimsonbreasted Barbet	Thirumani	*Albizzia lebbek*	4
	Madras	*Enterolobium saman*	4
	Delhi	*Tecoma indica*	8
		Morus alba	2
		Azadirachta indica	2
Common Myna	Thirumani	*Albizzia lebbek*	8
	Madras	*Delonix regia*	3
		Mangifera indica	2
		Dalbergia sissoo	2
	Delhi	*Tecoma indica*	5
		Ficus benjamina	3
		Dalbergia sissoo	2
Brahminy Myna	Thirumani	*Albizzia lebbek*	10
	Delhi	*Tecoma indica*	9
		Dalbergia sissoo	2

TABLE 4

HEIGHT AT WHICH NEST HOLES OCCURRED (IN METRES)

Nest No.	Roseringed Parakeet	Crimson-breasted Barbet	Common Roller	Common Myna	Brahminy Myna
1	7.62	6.70	3.66	9.45	7.62
2	7.62	6.10	5.49	4.27	5.18
3	9.14	3.66	6.10	3.96	5.49
4	9.14	6.10	6.10	8.80	5.49
5	7.62	4.57	7.62	5.49	5.18
6	9.14	3.10	8.00	7.32	6.40
7	6.10	1.52	—	7.62	5.71
8	7.62	2.44	—	5.49	4.57
9	7.62	3.00	—	12.1	3.66
10	13.72	5.49	—	13.72	6.00
11	—	—	—	9.14	6.00
12	—	—	—	9.14	6.70
13	—	—	—	10.67	5.49
14	—	—	—	10.67	—

TABLE 5

CIRCUMFERENCE OF THE OPENING OF NEST HOLES OF DIFFERENT SPECIES (IN CENTIMETRES)

Species	No. of observations	Mean	SD±	Range
Roseringed Parakeet ..	10	25	8.7	16-47
Crimsonbreasted Barbet ..	10	12	4.3	8-22
Common Myna ..	8	28	7.5	20-47
Brahminy Myna ..	10	16	5.0	8-25
Indian Roller ..	5	30	6.0	26-42

only a considerable time after the fledglings of the early breeder or the occupant flew out of the nest. In the clashes between the common myna and the roller, for occupation of the same nest hole, the myna always won. But if the roller had established itself in a nest hole, no other species could evict it. The rollers were, however, irresponsible parents neglecting the brood for long hours and thus losing the young. When this happens, they vacate the nest too, letting the nest hole be occupied by the common myna. In one instance, the roller parents guarded the nest for twelve days after losing the brood and then lost interest and vacated the nest which was readily taken over by the common myna.

Even though there is strong demand for the same breeding site between parakeet and common myna, it does not interfere with their nesting success as their breeding timing does not coincide, thereby giving time for the early breeder to complete its cycle. The time at which parakeet fledglings flew out of the nests and clashes between parakeets and mynas were observed are given in Table 6. The parakeets were obviously using the nest as a shelter in post-breeding season.

During the course of the study, a fierce

TABLE 6

TIME GAP BETWEEN NEST-LEAVING AND RE-OCCUPATION

Nest No.	Time of parakeet fledglings leaving the nest	Time of clashes
1.	4th week of March	.. 2nd week of May
2.	3rd week of April	.. 2nd week of May
3.	3rd week of April	.. 2nd week of May
4.	2nd week of April	.. 2nd week of May
5.	4th week of April	.. 2nd week of May
6.	3rd week of April	.. 2nd week of May

clash between a late breeding pair of parakeets and of rollers was seen in which the original occupant of the nest hole, the roller succeeded in retaining the nest. Competition between the Crimsonbreasted barbet and the Yellowthroated Sparrow for the same nest, was common in Thirumani study area. Each time the barbets successfully retained the nests, the sparrows had to be satisfied with some natural hollow or depressions in the dead branches of the trees. But a clear cut working adjustment was observed between barbet and Brahminy Myna. When barbets completed their breeding, the nest was taken over by Brahminy Mynas. However, in Delhi the Brahminy Mynas successfully drove out barbets and occupied their nests.

A species competing with the Brahminy Myna for the nest of the barbet was the Magpie Robin. Between them the Magpie Robin was successful every time. Spotted Owlets and Hoopoes also breed in tree holes and their breeding season was also from April to May. Owlets prefer rotten natural hollows and Hoopoes preferred some natural deep holes with two or three entrances. A General picture of the clashes between different species for the same nest is given in Table 7.

As already reported by Lamba (1963), perfec harmony was observed between the different species occupying neighbouring holes either in the same tree or trees nearby.

Nesting Success

While breeding success of hole nesters depends on their ability to find a suitable hole and hold it against competition, both inter-and intra-specific, nesting success is the ratio of young that flew from the nest to the number of eggs laid and is the end result of the breeding activities. The tree hole nesters showed variation in nesting success both within and among the species and at different places. The presence of predators, the quality of parental protection and the unequal distribution of food, were the main reasons of nesting failure. The breeding success was studied for Roseringed Parakeet, Indian Roller, Brahminy Myna, and Crimsonbreasted Barbet, both in Thirumani and in Delhi, the breeding success of Common Myna was studied in Thirumani.

In Thirumani, the Roseringed Parakeets under observation laid 28 eggs, of which 24 hatched (85%) and 19 flew out of the nest, making the nesting success 67.8%. However, in Delhi,

Table 7

Clashes for nest holes

Clashes seen between		No.	Won by	
Occupant species	Competing species		Occupant	Intruder
Crimsonbreasted Barbet	Yellowthroated Sparrow	6	5	1
Crimsonbreasted Barbet	Brahminy Myna	4	0	4
Brahminy Myna	Magpie Robin	3	0	3
Roseringed Parakeet	Common Myna	6	0	6
Indian Roller	Roseringed Parakeet	3	3	0
Indian Roller	Common Myna	2	1	1

of the 15 eggs laid, 11 hatched (66%) and only 5 nestlings flew out of the nest (33.3%).

Of rollers in Thirumani out of 11 eggs laid, 9 hatched (81%) and only 2 nestlings survived to leave the nest (18.2%). However, in Delhi, of 5 eggs laid, 3 were hatched (60%) and 2 nestlings flew out of the nest (40%).

Brahminy Mynas in Thirumani laid 32 eggs, of which 28 hatched (87%) and 16 nestlings successfully flew out (50%). In Delhi area, Brahminy Mynas laid 32 eggs, of which 28 hatched (87%) and 23 nestlings were reared successfully (71%).

Crimsonbreasted Barbets laid 6 eggs in Thirumani from which 2 hatched (33%) and of those 2 survived (33%). In Delhi, 11 eggs were laid of which 9 hatched (81%) and 7 nestlings survived to become adults (63.7%).

In Thirumani, Common Mynas laid 28 eggs from which 19 hatched (67%) and 8 were successfully reared (28.6%).

CONCLUSIONS

The percentage of young surviving to leave the nest, varies widely among different species. Within the same species also it varies geographically and seasonally.

In the present study, among different species of birds having common ecological niches for breeding, the Brahminy Myna and the Crimsonbreasted Barbet were found to have the highest nesting success. This is attributed to :—

(1) Safe nesting sites—for successful rearing of the offspring, the young have to be cared for, fostered, and protected. The birds have to select a site which helps to conceal the nests from predators and also provides food for themselves and the young ones. But at times, birds like the rollers and the Common Mynas tend to select unsuitable sites.

(2) The entrance of the nest holes are smaller in size in case of the barbets and the Brahminy Myna, which prevents the predator's access to the nests and also limits intra-species competition. In spite of the thick vegetation the wider entrance of the holes of roller and common mynas provide easier access for the predators.

(3) Nesting success depends also upon the parents in providing food for the young ones. Rollers were found to be inefficient parents. The youngest in the nest seldom receives its share of food as it is shoved away by its elder siblings when the parent brings the food. Hence starvation results in mortality.

(4) *Predation :* Human predation had a marked influence, in the case of parakeets, on the Delhi population and the Thirumani data with 67% nesting success without human predation gives a true picture.

For the other species, predators of eggs were monkeys, House Crows and Jungle Crows and predators of nestlings were monkeys, House Crows, Jungle Crows, Brahminy Kites, and ants of *Camponotus* species.

In addition, nests were destroyed by rain, and high winds. An unexpected storm took toll of some trees which had the broods of barbets in Thirumani, hence nesting success was reduced to 33% for that breeding season and the data does not give the correct picture of the normal breeding success of the species in that area.

In general, hole nesting has certain advantages and disadvantages. Nice (1957) has reported that out of 7788 nests studied, the survival rate of hole nesting species average 66%. Nests are built in relatively inaccessible sites. These species breed solitarily which increases concealment under the thick vegetation. Breeding in thick vegetation with wide spacing presumably diminishes the chance of their being found by predators.

The birds which build the nests in unprotected places, have the compensatory advantages of a much wider choice of nesting sites in relation to the food supply and can occupy many different habitats. But the birds dependent on tree holes, may not find enough safe holes.

Another disadvantage would be the inability of the young to scatter when attacked by a predator, therefore the loss from a predator once it makes a successful entry into the nest, could be total. The loss at egg stage would be equal for open nesting and hole nesting forms but will be more at nestling stage for hole nesters. However, this disadvantage would be offset by the fact that hole nest is more easily defended.

ACKNOWLEDGEMENT

I am indebted to Dr. Sálim Ali and Mr. J. C. Daniel for advice and encouragement. This paper formed part of a M.Sc. thesis submitted to the University of Bombay.

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THE STATUS OF INDIAN CROCODILIANS

ROMULUS WHITAKER[1] AND J. C. DANIEL[2]

(*With two plates*)

INTRODUCTION

Crocodilians have been singularly unsuccessful in the 20th century. Most of the generally recognized 22 species survive exclusively in national parks, protected preserves and in farms and breeding stations. This non-success is due mainly to (*a*) the hunting for skins on a very wide scale with, till recently, very little or no restrictions on numbers and seasons and (*b*) habitat loss. The world market for crocodilian skins used to peak over 2,000,000 skins per annum. As late as 1976 the Colombian Government issued licenses for huning 290,000 caiman (IUCN 1971).

The three species of Indian crocodilians are the mugger or marsh crocodile (*Crocodylus palustris*), the saltwater or estuarine crocodile (*Crocodylus porosus*), and the gharial (*Gavialis gangeticus*). Of these the mugger has been the most successful ecologically, adapting to a wide habitat range from hill streams and rivers to ponds, marshes and lakes. Gharials are restricted to deep, fast flowing northern rivers and estuarine crocodiles to coastal creeks and mangrove swamps.

METHODS OF STUDY

From 1973 on the Madras Snake Park Trust and the Bombay Natural History Society have sent questionnaires throughout the country enquiring about the status of crocodilians. Field workers of the Madras Snake Park have made survey trips or visits to all the states with known crocodile populations. Considerable correspondence and searching in old literature helped ascertain past status and distribution of India's crocodilians.

RESULTS AND DISCUSSION

Mugger were once extremely common in the former wide range from Dasht in the extreme west of Pakistan to Assam in north-eastern India and over most of the peninsula and Sri Lanka (Smith 1931).

Estuarine crocodiles were plentiful in the Sunderbans in West Bengal, Bhitar Kanika in Orissa (Daniel & Hussain 1974) and the Andamans and Nicobar Islands, since these areas support extensive mangrove swamps and tidal creeks. Other populations also existed along the southern east and west coasts but were already rare in the 1940's. Kerala, which today has no mangrove left, evidently once had a substantial population of estuarine crocodiles.

Old accounts, such as those of Andrew Leith Adams (1867), indicate how plentiful gharial used to be in northern rivers : 'The gavial or Indian alligator (*Gavialis gangeticus*) abounds in all the great rivers of Northern India . . . Ten or twenty may be frequently seen together . . .' Their range extended through-

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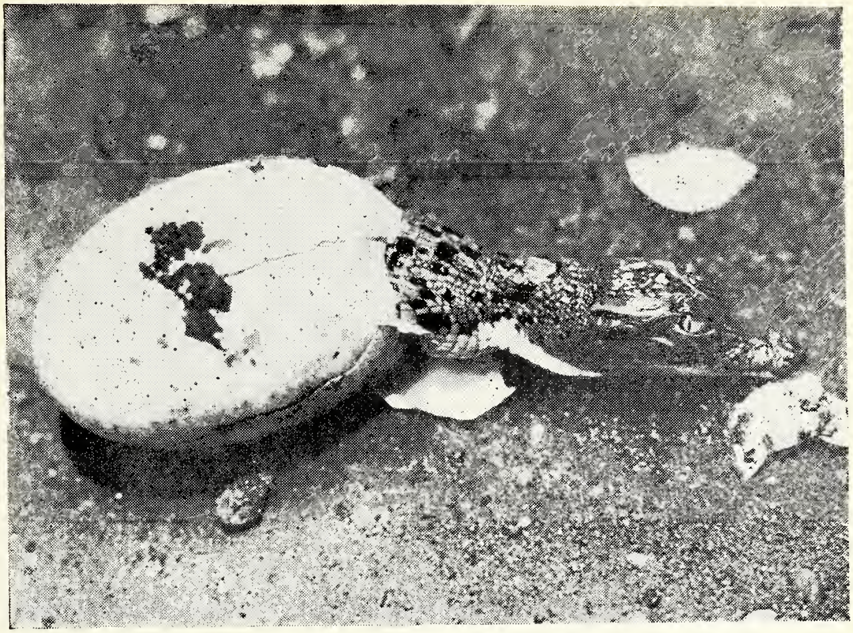
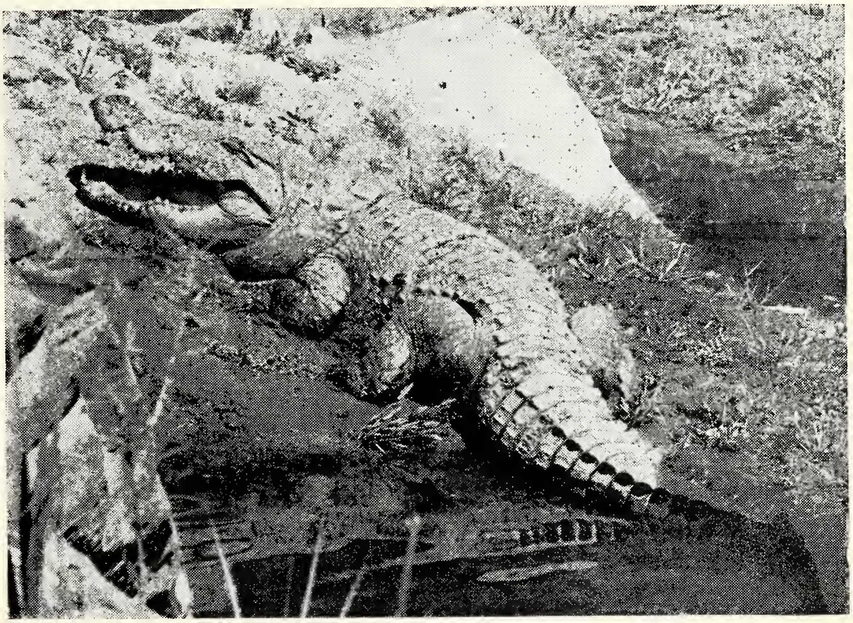
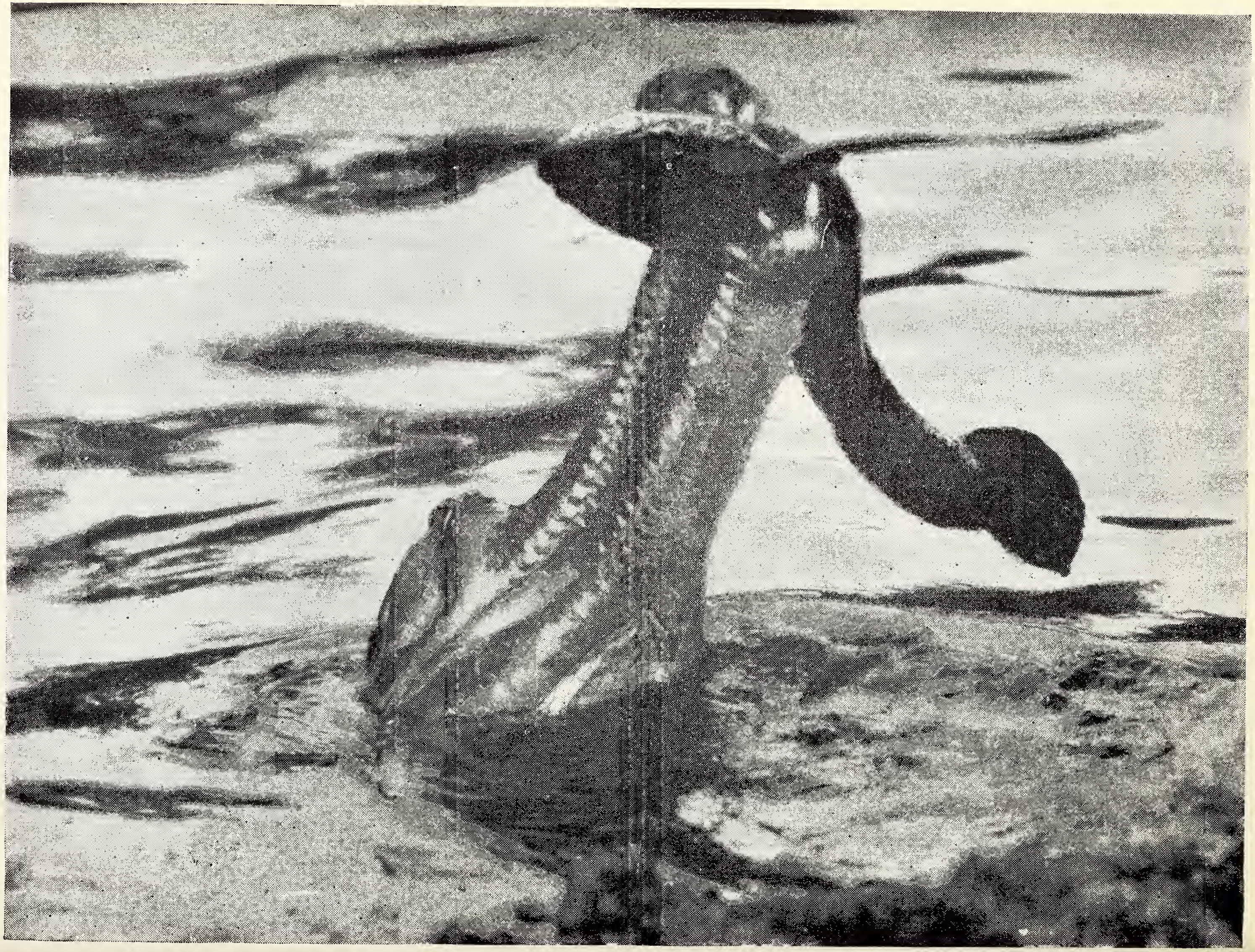
Whitaker & Daniel : Indian Crocodile



Estuarine Crocodile (*Crocodylus porosus*) hatching (Andamans).



Marsh Crocodile (*Crocodylus palustris*) in natural habitat (Corbett National Park).



out the Gangetic system, west to Pakistan and north-east to the Brahmaputra, with an isolated population in Orissa in the Mahanadi. Another early naturalist, Hornaday, in 1880 reported seeing 24 gharial in two hours on the Yamuna River, not far from Allahabad (Hornaday 1881).

Depletion :

The general reasons for the decline of the three species are uncontrolled and all-season hunting for hides, meat, ' medicine ' and sport ; killing by fishermen ; extensive collection of eggs for eating, and loss of habitat caused by dam construction, river diversions, agricultural and forestry activities, water pollution and human disturbance and encroachment. It was recently observed that the gharial on the Karnali River (a group of seven adults) in Western Nepal failed to breed in 1976 because of the disturbance caused by a dam feasibility project (Whitaker 1976). Natural predation in crocodiles, especially in the egg and hatchling stage, is very high and gains importance in dangerously low populations, as is the case with India's three species. It is estimated that only 1-2% of hatchling crocodiles reach adulthood in nature.

The Skin Industry :

From interviewing skin dealers it is evident that a few people once made considerable profits on crocodile skins. Fishermen supplied the skin markets of Agra and Kanpur, whereas in other areas tribal crocodile hunters (operating throughout the north) supplied middlemen. In some parts of the country one or two ' specialist ' hunters were apparently responsible for wiping out considerable populations. One well-known ex-hunter in Diglipur, North Andaman, claims to have killed a thousand crocodiles during his 15 year career.

With the 1972 ban on crocodile killing, the skin market went underground. The value of crocodile meat, fat, gall bladder (for ' medicinal ' uses) and other parts still makes it worthwhile to kill crocodiles even without the danger involved in selling the skin. In ' country medicine ' shops throughout the country crocodile fat is a rare but available ' remedy ' for asthma, whooping cough or rheumatism.

The only available statistics on the Indian crocodile skin industry are for 1964-65 when a total of Rs. 25,948 worth of skins were exported to U.K. and France. The absence of statistics makes it difficult to assess the size of the industry (Bhanotar *et al.* 1975).

Legal Status and Protection :

Before the export of crocodile skins from India was controlled in 1969 (Instruction No. 57/75), crocodiles in some areas received protection as religious symbols. In some parts of Kerala it was customary to have a resident mugger in temple tanks and these were zealously protected by the villagers. The famous Mugger Pir near Karachi in Pakistan still exists today and here the last three resident mugger are venerated and fed by the local people. Effective and thorough ' paper ' protection for Indian crocodilians was accomplished only in 1972 (Wildlife Protection Act, 1972). The three species are listed under Schedule 1 of the Act, rendering the killing, trapping, transporting or being in possession of a crocodile or its products without a special permit illegal with a penalty of upto 6 months imprisonment and Rs. 2,000 fine. Export instruction No. 46/73 forbids the export of crocodiles and gharial, their hides, or products therefrom.

Present Status :

State by state status accounts are given in Tables 1, 2, 3 and 4. Madras Snake Park field investigations have covered most states but only Tamil Nadu in great detail.

TABLE 1

PRESENT STATUS OF MUGGER (*Crocodylus palustris*)

State	Habitat	Estimate of numbers	Remarks
TAMIL NADU	Chidambaram Waterworks.	15-20	4 breeding females. Good protection from Municipality.
	Kilikudu 'Crocodile Farm'.	20	5 breeding females. Complete protection by local villagers and the Forest Department.
	Mettur Reservoir	Less than 10	
	Sathanur Reservoir	12	6 breeding females. State Crocodile Project site.
	Bhavani Sagar Reservoir	Less than 10	
	Kedarhalla and Moyar Stream.	Less than 10	6 breeding females. Recommended as Crocodile Preserve.
	Amaravathi Reservoir	25	12 breeding females, State Crocodile Project site.
	Hogenekal Falls (Cauvery R.).	Less than 10	3 breeding females.
Tamil Nadu has less than 200 wild crocodiles but this is the largest confirmed population in the country.			
KARNATAKA	Ranganathittoo Bird Sanctuary (Cauvery R.).	Less than 10	1 breeding female.
	Other rivers (other parts of Cauvery, Kabini, Thungabhadra, Nugu, etc.).	Very few, totalling less than 100.	
A State Crocodile Project has been initiated at Bannerghatta National Park, near Bangalore.			
KERALA	Neyyar Reservoir	Less than 10	1 nesting female. One of the sites for the State Crocodile Project.
	Parambikulam Reservoir.	Less than 5	1 breeding female.
The total crocodile population of Kerala probably does not exceed 30.			
ANDHRA PRADESH	Godavari R.	Less than 10	
	Krishna R.	Less than 10	
State Crocodile Project for *C. palustris* and *C. porosus* initiated in 1976.			

Maharashtra	Borivli National Park	Less than 10	
	Tadoba National Park	Less than 20	
	Other Parks and Rivers	*c* 50	
	Population probably less than 100.		
Madhya Pradesh	Large rivers e.g. Mahanadi, Son, Betwa, Ken.	Less than 100	
Mugger formerly very plentiful in tanks and rivers. Forest Dept. is taking conservation measures.			
Orissa	Major rivers like Mahanadi, Bahmani, small reservoirs, tanks.	Less than 20	
No breeding population known. Extensive State Crocodile Project commenced in 1975, with a mugger rehabilitation centre at Simlipal.			
Gujarat	Hiran Lake (Gir National Park).	60	6 nests located in 1977.
	Other reservoirs and tanks in the State.	Small remnant populations.	
Gujarat has the second largest mugger population in the country and the Forest Dept. has initiated a crocodile rehabilitation project.			
Rajasthan	Chambal R.	Less than 20	
	Reservoirs and tanks	Few isolated individuals	..
A State Crocodile Project was initiated in 1975.			
Uttar Pradesh	Ramganga (Corbett National Park)	8	
	Rivers, streams	Under 100	
Large scale State Crocodile Project underway since 1975.			
Bihar	Remote rivers and jungle lakes	Total less than 50	
Some rehabilitation work has been started by the Forest Department.			
West Bengal	Ganga and other rivers	Under 30	
A project for the three species has been commenced by Forest Department.			
Assam	All rivers	No mugger reported in recent years.	
Mugger seem to be extinct in Assam.			

Table 1

Present Status of Mugger (*Crocodylus palustris*)

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<tr><td></td><td>Parambikulam Reservoir.</td><td>Less than 5</td><td>1 breeding female.</td></tr>
<tr><td colspan="4">The total crocodile population of Kerala probably does not exceed 30.</td></tr>
<tr><td>Andhra Pradesh</td><td>Godavari R.</td><td>Less than 10</td><td></td></tr>
<tr><td></td><td>Krishna R.</td><td>Less than 10</td><td></td></tr>
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<tr><td>Madhya Pradesh</td><td>Large rivers e.g. Mahanadi, Son, Betwa, Ken.</td><td>Less than 100</td><td></td></tr>
<tr><td colspan="4">Mugger formerly very plentiful in tanks and rivers. Forest Dept. is taking conservation measures.</td></tr>
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<tr><td>Rajasthan</td><td>Chambal R.</td><td>Less than 20</td><td></td></tr>
<tr><td></td><td>Reservoirs and tanks</td><td>Few isolated individuals</td><td></td></tr>
<tr><td colspan="4">A State Crocodile Project was initiated in 1975.</td></tr>
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</table>

TABLE 2

PRESENT STATUS OF ESTUARINE CROCODILE (*Crocodylus porosus*)

State	Habitat	Estimate of numbers	Remarks
WEST BENGAL	Sunderbans	No census—few remain	State Crocodile Project since 1976.
ORISSA	Bhitar Kanika Islands (Bahmani Delta).	80-100	Saltwater Crocodile Research and Rehabilitation Centre at Dangmal.
ANDAMANS AND NICOBARS	Mangrove fringe and tidal creeks in most of the large islands.	No census	Heavily depleted from hunting and habitat loss. Only surviving healthy populations in Little Andaman and parts of the Nicobars.

TABLE 3

PRESENT STATUS OF THE GHARIAL (*Gavialis gangeticus*)

State	Habitat	Estimate of numbers	Remarks
UTTAR PRADESH	Katerniaghat (Girwa River)	App. 20	Largest concentrated wild gharial population in India. State Crocodile Project site.
	Chambal River	Small breeding group	
	Ramganga River (Corbett National Park).	4	
	Jamuna, near Allahabad	Seasonally a few	
RAJASTHAN	Chambal River	40	State Crocodile Project for gharial on Chambal.
MADHYA PRADESH	Mahanadi River	3	
	Chandia River	2	
	Tons River, Kertu	Less than 5	
	Ken River, Mandla Sanctuary.	Less than 5	
ORISSA	Mahanadi River, Satkoshia Gorge.	7	
Total wild population in Orissa not more than 10. A Gharial Research and Rehabilitation Centre has been established at Tikerpada, Satkoshia Gorge.			
ASSAM	Subansiri River	Less than 5	
Total in Assam: 10.			
BIHAR	Gandak, Kosi	Under 10	
A rehabilitation project is underway.			

TABLE 4

CROCODILES ON THE SUB-CONTINENT

Country	Species	Status	Remarks
SRI LANKA	*C. palustris* *C. porosus*	*C. palustris* plentiful, status of *C. porosus* not known.	No big skin industry ; limited killing locally for meat & fat.
BURMA	*C. palustris* *C. porosus* *G. gangeticus*	*C. palustris* and gharial extinct. Few isolated *C. porosus* in Irrawaddy.	Legalized skin export.
PAKISTAN	*C. palustris* *G. gangeticus*	*C. palustris* very rare. Less than 20 *G. gangeticus*.	Full protection.
BANGLADESH	*C. porosus* *G. gangeticus*	A few *C. porosus* in the Sunderbans, *G. gangeticus* extinct. *C. palustris* not reported.	
NEPAL	*C. palustris* *G. gangeticus*	Few *C. palustris* in tanks and rivers. About 50 *G. gangeticus* remain in rivers like Karnali, Makali, Rapti-Doon and Marayani.	Full protection.

CONSERVATION

In 1974 Government of India invited Dr. H. R. Bustard, FAO/UNDP Crocodile Consultant to advise on crocodile conservation and management schemes. Under the initiative and guidance of Dr. Bustard several state Governments have established crocodilian projects, which include incubation of eggs, rearing of young and release in preserves. These projects also have the academic participation of several full-time Ph.D. scholars working on crocodilian biology. The gharial research and rehabilitation units in Orissa and U.P. have had remarkable success and are currently rearing over 500 gharial hatched from wild-laid eggs which will be released in the adjacent protected areas. On 9th April 1977 the first 2 year old gharial over a metre long were released into the Mahanadi at Satkosia Gorge. Four sanctuaries have been created for the gharial: Orissa (Satkosia Gorge, Mahanadi River), U.P. (Katerniaghat, Girwa River), Bihar (near Nepal border, Gandak River) and Rajasthan (near Kota, Chambal River). Bhitar Kanika in Orissa is now a sanctuary for the estuarine crocodile. The survival of India's three crocodilians depends on the success of these projects.

Tamil Nadu has the potential for the largest mugger rehabilitation scheme in the country. In 1977 the Tamil Nadu Forest Department has collected over 600 eggs from wild nests and is rearing about 150 hatchlings from 1976 egg collection. Hatcheries and rearing ponds have been set up at Sathanur, Madras, Amaravathi and Hogenakal. In addition, several areas that are important crocodile habitats are under consideration as crocodile preserves. During 1976 Andhra Pradesh and Kerala initiated mugger conservation projects. At least 2 mugger have been released in protected habitats in Andhra.

Gujarat State, which has the second largest known mugger population after Tamil Nadu is reported to have a project proposal for the Gir crocodiles. It would be advantageous if crocodile conservation measures could be taken up state wide. States such as Madhya Pradesh and Karnataka have remained mostly inactive with regard to crocodile rehabilitation. With the current interest and involvement of the Govt. of India and FAO/UNDP in crocodile conservation it would be timely for all states to take advantage of this and develop projects for the rehabilitation and management of this resource. The FAO/UNDP aided schemes aim to help recuperate crocodile populations to a safe, viable level in protected wild habitat. Simultaneously the technology of captive rearing (and eventually breeding) is being studied and developed for eventual farming. The programme envisages eventual culling of surplus animals, large scale battery type farming as well as crocodile farming as a 'cottage industry' as in Papua/New Guinea (Pooley 1976). The Andamans and Nicobars are in particular need of attention. The estuarine crocodile could be ensured a future there and a major forest based industry could grow from a carefully managed programme.

Sustained protection of our crocodilian resources is possible only through clear consideration of all the factors. The fisheries interests and the public must be convinced of the value of crocodilians in the eco-cycle of India's aquatic and estuarine environments. Personnel with the aptitude and interest in the specialized field of wild animal husbandry must be located and trained. We must be certain that we do not create too big a market for farmed skins to fulfil which would again place increasing pressure on wild stocks. Aspects such as genetic stock and in-breeding must be studied in this initial phase of 'domesticating' a wild species. The carrying capacity of all previous or potential crocodilian habitat will have to be critically determined to guide release programmes. Similarly, monitoring and studies on existing wild and released populations will guide our management and sustained yield cropping policies.

The Madras Crocodile Bank, a joint project of the Madras Snake Park Trust and the World Wildlife Fund was initiated in 1974 to breed and rear the 3 species of Indian crocodilians for conservation purposes. This year (1977) the Bank has for the third consecutive year had breeding success with mugger, and hopes to breed estuarine crocodiles and gharial in the future. The Bank possesses 130 mugger, 8 estuarine crocodiles and 3 gharial and has received support from the State Govt. The Tamil Nadu Tourist Development Corporation recently granted Rs. 50,000 to the Bank for developing the touristic and educational aspects of the Bank. The M. C. B. has supplied hatchlings to the forest departments of Kerala, Tamil Nadu and Orissa for their rearing projects and is aiding crocodilian conservation by public education, advice to state projects and the development of crocodile farming technology.

The Future :

Like most wildlife in India, crocodilian survival is threatened primarily because of value placed on skin, meat, eggs and other parts and secondly from increasing human pressure on the environment. Protection, public education and human population control are needed to ensure their survival. Meanwhile the most valid argument to offset the destruction of species like the crocodile is that these resources can be carefully managed for captive farming and free range sustained yield exploitation. If we can accomplish the marketing of farmed products only, we have paved the way for the survival of wildlife.

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NOTES ON THE HOST PLANTS OF THE LORANTHACEAE IN THE NILGIRIS

Priya Davidar[1]

Fischer in 1926 contributed extensively to our knowledge of the host affinities of the loranthacean plant parasites or the mistletoe of south India. However, little work has been done since then on the host ranges and affinities of these species, but for the host range of a few species recorded by Narasimha and Rabindranath (1964). I made some observations and notes on the host range of the loranthacean species in the Nilgiris during the course of a two-year study on ornithophily.

In this paper the name loranthus is used as a common name to indicate the semi plant parasites that fall under the family Loranthaceae. A recent development in the classification of the mistletoe has been the formal separation of the Loranthaceae into two separate families Loranthaceae and Viscaceae (Kuijt 1969).

The host plants of the Loranthaceae listed in this paper is neither complete nor exhaustive. However, some interesting host-parasite combinations are dealt with, and an effort made to identify the causes that may underlie them, as this could lead to a greater understanding of their phylogeny and evolution.

The study area, the Nilgiri Hills, lies between latitude 11° 8′ and 11° 37′ N., and longitude 76° 27′ and 77° 4′ E. The area receives rainfall from both the NE and the SW monsoons. The differences in rainfall, temperature and altitude in different parts of the district contribute to make the flora of this district varied and rich. Heavy rainfall on the western slopes supports a moist evergreen forest at elevations between 900 m and 1200 m. Slopes with less rain have a moist mixed deciduous type of forest, and in dry areas the dry deciduous forest. At about 1500 m the southern subtropical hill forest, the transitional belt of the shola forest intergrades with the shola forest. The southern montane wet temperate forest or the shola forest occurs above 1700 m, and is confined to the hollows and ravines on the hillsides. The southern montane wet grasslands cover large areas on the hillsides.

Several reasons have been put forward to explain the inability of a loranthus to establish itself on certain plants. The mechanical properties of the host species bark that prevent penetration by the haustoria of the parasite, the biochemical incompatibility of the parasite and host systems, and the light or shade requirements of the loranthus are some of them. The habits and movements of the birds that disperse the seeds of this parasite could also play a large role in determining the host species (Kuijt 1969).

One of the obvious reasons for the restriction of the host range of a certain species of loranthus is its limitation to a certain biotope or vegetational type, by environmental factors. This limits the number of host species the loranthus can parasitise. In the Nilgiris, loranthi such as *Dendrophthoe neelgherrensis* and *D. memecylifolia* are limited geographically to the montane evergreen forests as they occur only above a certain elevation on the southern hills. Other species such as *Scurrula*

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cordifolia and *Helixanthera intermedia* have a wider altitudinal tolerance and occupy two or three vegetational zones on the slopes. *Helixanthera intermedia* occurs between the altitudes of 1000 m-2000 m and straddles two to three vegetational zones. In the lower elevations it is found in the moist deciduous type of vegetation, where the tree predominantly attacked is *Toona ciliata.* Its range extends through the subtropical hill forest to the shola forest proper where its commonest host plant is *Symplocos laurina. Dendrophthoe falcata* possesses a high degree of adaptability to different environmental conditions. It has a very wide host range with 343 recorded host plants (Narasimha and Rabindranath). It is an extremely polymorphic species and two different forms may not seem to have much resemblance to each other, and intermediate forms also occur. Wiens (1971) maintains that due to the extreme variation of forms and their lack of geographical consistency the variety subgrouping serves no useful purpose. However, I feel that the varieties should be delimited as it would make the different forms easier to describe. Besides there is strong evidence to suggest that the habit of this parasite varies with the habitat in which it is found. The form with long leathery leaves and yellow flowers is found in the dry deciduous biotope. This habit is possibly an adaptation to xerophytic conditions. The plants it commonly parasitises are *Zizyphus mauritiana, Z. xylopyra, Acacia* spp., and *Albizzia* spp., the dominant trees in dry deciduous forest. The form with white flowers and falcate leaves occurs most commonly in the moist mixed deciduous forests, and it may occur to a less extent in wetter and in drier areas. The form with amplexicaule leaves is found in much wetter conditions on the slopes from 625 m to the shola forests. There is a significant amount of geographic consistency between the different forms and isolating mechanisms possibly operate to make them more distinct from each other.

In *D. falcata* with amplexicaule leaves, colour of the flower varies from deep red to pink. In the sholas the trees most commonly attacked by this loranthus are *Syzygium cuminii, S. arnottianum,* and less often the shrub *Rhodomyrtus tomentosa.* There is a possibility that it extended its range up the hillside by parasitising a tree species also common in lower elevations. Another common host is the woody climber *Dalbergia gardneriana.* This climber grows over several trees in the shola forming a tangle of vegetation. In one instance the climber was heavily infested with *Dendrophthoe falcata,* while not a single clump was found on any of the trees supporting the climber.

In a mixed forest certain species are found to be highly host selective. It would be interesting to know why a loranthus confines itself to a few host species when there is an ample choice of hosts. In the temperate regions with stands of a single or a few species of trees it may be advantageous for the mistletoes to be host selective (Kuijt 1969). Though in a heterogenous tropical forest a high degree of host selectivity seems disadvantageous unless the parasite has also evolved a successful dispersal system to propagate the parasite onto the required host. More study is required before it is established whether loranthus with a wide host range is more or less successful or advanced than loranthus with a limited host range (though success in parasitism cannot necessarily be equated with an advanced nature).

Helixanthera hookeriana is a loranthus confined to the altitudinal zone of 1200-1700 m on the slopes of the western ghats complex. In the Nilgiris it is found in the moist mixed deciduous tract on the slopes. I have recorded this loranthus on only one species of host *Mallotus philippinensis.* Fischer in

1926 recorded this loranthus on the above host species only. The reasons for such a narrow host range in a forest supporting numerous species of trees and shrubs is not, as yet, known. The limited geographical distribution and narrow host range of this loranthus could indicate an advanced nature though it also makes it vulnerable to extermination. This is an entomophilous species unlike the rest of the species in this district that are ornithophilous. The few species in this genus whose pollination has been studied are known to be ornithophilous though also visited by insects. *Helixanthera hookeriana* has bisexual flowers, and its structure suggests an ornithophilous ancestry. With exceptions typical insect pollinated loranthus are unisexual (Kuijt 1969). Entomophily in this case suggests an advanced nature. The fruits are dispersed by the flowerpecker.

All the species of loranthus in the Nilgiris are propagated by birds. The most common agent for dispersal is the flowerpecker, *Dicaeum concolor*. At lower elevations both *Dicaeum agile* and *D. erythrorhynchos* are present. Nearly all the species of loranthus in the Niligiris are dispersed by *Dicaeum*, the common method is by discarding the epicarp, swallowing the viscid seed and excreting it on to a branch (Sálim Ali 1931). However, *Macrosolen parasiticus* is also dispersed by frugivorous birds such as bulbuls and the barbets.

Dendrophthoe memecylifolia, an endemic Nilgiri mistletoe found above 1700 m has a very limited host range, most often, if not always, the tree parasitised being *Vaccinium leschenaultii*. Fischer's paper in 1926 lists five host plants for this parasite. I have recorded it on four host plants, three of which are common with Fischer's list. I have found this parasite only once each on the host species other than *Vaccinium leschenaultii*. To give an example: in a hectare of shola forest comprising of numerous shola trees, 10 out of the 17 *Vaccinium leschenaultii* were parasitised by *Dendrophthoe memecylifolia*. This loranthus was not found on any other shola tree. *D. memecylifolia* produces a very limited number of fruits by comparison with the other loranthi. The fruiting period is very short, and the fruits are dispersed by *Dicaeum concolor*. The fruits of *D. memecylifolia* start to ripen when *Vaccinium leschenaultii* is in fruit though past its peak. The fruits of *V. leschenaultii* are a great favourite with *Dicaeum concolor* and the birds move from one tree to another feeding on them. I have observed the bird consume a few fruits of the loranthus along with those of the host, and possibly the seeds are excreted on the next tree the bird visits. Apparently, birds could be one of the important factors that determine the host plant of *D. memecylifolia*.

In *Macrosolen capitellatus* which occurs upto an elevation of 1500 m, flowerpeckers (observed species *Dicaeum concolor*) use a different technique to disperse the seed. The flesh alone is eaten, the epicarp is dropped and the seed is rubbed off from its bill onto a branch. The bird plucks a fruit, flies a short distance away to a bare branch and proceeds to eat the flesh. Usually the bird stays close to the source of berries repeatedly visiting the clump for more fruit. As the seed is not taken to a distance it is common to see a tree fully infested with this loranthus.

Many cases of hyper-parasitism have been recorded, and usually *Viscum* parasitising a loranthus is common. In these cases too the bird plays the major role.

In Coonoor the fruiting of the loranthus is spread over the year. Thus the bird does not have more than one to three species of loranthus in fruit to contend with at any given time of the year. The activity of the *Dicaeum* may differ at different times of the year, and this could also be a reason why a host species sometimes supports only a certain species of loranthus and not others. Though ringed birds have not been followed, the *Dicaeum* is apparently territorial around a few clumps of loranthus in fruit, and apparently restricts its feeding to that area. The perch preference of the *Dicaeum* could also determine the subsequent dispersal of the seed. A small bird like the *Dicaeum* would normally prefer thinner branches to perch on.

Light is an important controlling factor in the distribution of loranthus in a forest, light tolerant or the light intolerant species selecting habitats as per their requirements. *Helixanthera intermedia* above 1500 m predominantly parasitises *Symplocos laurina*, and one of the factors could be that *Helixanthera intermedia* is a light tolerant branch inhabiting loranthus, and this particular host plant could offer possibilities for exposure to light. *Helixanthera intermedia* growing in shady conditions show listless growth and poor flowering, the flowers being pale. *Taxillus cuneatus*, *T. recurvus* and *Helixanthera wallichiana* appear to be light tolerant. *Dendrophthoe memecylifolia*, *D. neelgherrensis* appear to be light intolerant. Though some species of loranthus including *D. neelgherrensis* grow both in light and shaded conditions.

Certain species have a wide host range. *Dendrophthoe neelgherrensis* which occurs above 1500 m and is a highly successful parasite of many of the indigenous as well as the introduced vegetation. It is the only loranthus that has parasitised *Eucalyptus globulus*. It had been suggested that the eucalyptus due to rapid exfoliation of its bark does not encourage attack by the loranthus (Bidie 1874). Since then it has been noted that the loranthus does attack *Eucalyptus globulus* (Fischer 1926). *Eucalyptus ficifolia* is parasitised by *Macrosolen parasiticus*. I have seen *D. neelgherrensis* not only on the extremities of the branches of *E. globulus* but also on the main trunk where the bark is shed rapidly. *Dendrophthoe neelgherrensis* 'travels' along the branches of the host by means of epicortical roots, producing haustoria at intervals. Epicortical roots are not true roots as they arise from the base of the plant and not from the radicle. Loranthus such as *Dendrophthoe memecylifolia*, *Taxillus cuneatus*, *T. recurvus*, and *Macrosolen parasiticus* produce epicortical roots, and *Dendrophthoe falcata* with amplexicaul leaves, *Helixanthera intermedia*, and *Helixanthera hookeriana* do not have epicortical roots. Trunk inhabiting loranthus seem prone to developing epicortical roots, even within a species the clump on the trunk produces more epicortical roots than that on a thin branch.

The introduced *Acacias* from Australia are attacked by most of the loranthus. Fruit trees like the plum, peach and pear are most suspectible to attack by *Taxillus recurvus* and *Taxillus cuneatus*. Many other introduced species of trees and shrubs are attacked by many species predominant among them being *Dendrophthoe neelgherrensis*, whereas some species of loranthus are not found on any exotic vegetation at all. Fischer notes that Monocotyledons are not attacked bythe mistletoe. However in Ooty Botanical Gardens I have seen *Taxillus recurvus* parasitising *Cordyline australis* of Agavaceae, a monocot introduced from New Zealand.

Resemblance between the foliage of the loranthus and that of its host is rare. The resemblance, if present may be accidental. However, the foliage of *Dendrophthoe memecylifolia* resembles that of its main host plant *Vaccinium leschenaultii* to such an extent that it is difficult to make out the parasite in vegetative condition. The host plants of a species of loranthus generally do not have any similarity or relationship to each other, though *Dendrophthoe trigona* is found very often on species of *Ficus*. The loranthus and its host plant do not have a common pollinating agent, nor does it appear that flowering in the host influences flowering in the parasite.

The little that is known about the host preferences of the parasite, could be augmented by detailed study on loranthus seed germination, penetration and successful parasitism of various host plants. The influence of factors like rainfall, humidity, temperature, and passage of the seed through the alimentary canal of the bird on germination needs to be known. The habits and movements of the birds involved in loranthus propagation merit study to determine the role they play in host selection. The life span of a clump of loranthus needs to be determined. I have noticed clumps of loranthus dying for apparently no reason on a perfectly healthy host plant. Detailed study would possibly clarify the main factor or factors involved in host selection. The damage done by the loranthacean species on natural vegetation and cultivated plants needs to be assessed.

List of host plants of the Loranthaceae

Species of loranthus	Species of host
Helixanthera hookeriana (W. & A) Danser M. Arg. (1200 m-1700 m)	*Mallotus philippinensis* M. Arg.
Helixanthera intermedia Wt. (Danser) (900 m-2200 m)	*Gordonia obtusa* Wall.
	Toona ciliata Roem.
	Ilex wightiana Wall.
	Meliosma pinnata (Roxb.) Walp.
	* *Acacia melanoxylon* R. Br.
	Photonia notoniana W. & A.
	Symplocos laurina (Retz.) Wall., Rehd. & Wills.
	Dendrophthoe falcata (Linn.f.) Etting.
Scurrula parasitica Linn. (300 m-2500 m)	*Toona ciliata* Roem.
	Dalbergia lanceolaria L.f.
	Dalbergia latifolia Roxb.
	Acacia caesia Willd.
	Acacia sp.
	Albizzia sp.
	Anogeissus latifolia Wall.
	Premna cordifolia W.
	Emblica officinalis Gaertn.
Taxillus recurvus (DC.) van Tieghem (1500 m +)	*Meliosma simplicifolia* (Roxb.) Walp.
	* *Acacia dealbata* Link.
	* *Acacia melanoxylon* R. Br.
	* *Prunus domestica* Linn.
	* *Prunus persica* (Linn.) Batsch.
	* *Pyrus communis* Linn.
	* *Nerium odorum* Soland.
	* *Cinnamomum camphora* Nees
	Elaeagnus kologa Schlecht
	Glochidion neilgherrense W.
	Celtis wightii Pl.
	Salix tetrasperma Roxb.
	* *Cordyline australis* (Forst.) Hook. f.

SPECIES OF LORANTHUS	SPECIES OF HOST
Taxillus cuneatus (Roth)	* *Cryptomeria japonica* (Linn. f.). D. Don
	* *Citrus aurantium* Linn.
	* *Citrus medica* Linn.
	* *Hibiscus rosa-sinensis* Linn.
	Meliosma simplicifolia (Roxb.) Walp.
	* *Acacia dealbata* Link.
	Photonia lindleyana W. & A.
	* *Prunus domestica* Linn.
	* *Prunus persica* (Linn.) Batsch.
	* *Prunus cerassoides* D. Don
	* *Pyrus communis* Linn.
	Syzygium cuminii (Linn.) Skeels.
	Wendlandia thyrsoidea (Roem. & Schult.) Steud.
	Maesa perrottetiana A.DC.
	Ligustrum perrottetii A.DC.
	Lasiosiphon eriocephalus DC.
	Celtis wightii Pl.
	Salix tetrasperma Roxb.
Dendrophthoe falcata (Linn. f.) Etting widespread	*Bombax ceiba* Linn.
	Toona ciliata Roem.
	Zizyphus mauritiana Lamk.
	Zizyphus xylopyra (Retz.) Willd.
	Mangifera indica Linn.
	Dalbergia gardneriana Benth.
	Dalbergia latifolia Roxb.
	Acrocarpus fraxinifolius Wt.
	Tamarindus indica Linn.
	Acacia ferruginea DC.
	* *Acacia dealbata* Link.
	* *Acacia melanoxylon* R. Br.
	Acacia leucophloea Willd.
	Albizzia sp.
	Terminalia chebula Retz.
	Anogeissus latifolia Wall.
	Rhodomyrtus tomentosa Wt.
	Psidium guajava Linn.
	Syzygium arnottianum Walp.
	Syzygium cuminii (Linn.) Skeels.
	Tristania conferta R. Br.
	Maesa perrottetiana DC.
	Tectona grandis L.f.
	* *Grevillea robusta* A. Cunn.
	Mallotus philippinensis M.—Arg.
	* *Celtis serotina* Pl.
	Celtis wightii Pl.
	Morus alba Linn.
Dendrophthoe trigona (W. & A.) Dans. (900 m)	*Dalbergia latifolia* Roxb.
	Ficus bengalensis Linn.
	Ficus mysorensis Linn.
	Ficus glomerata Roxb.
	* *Nerium odorum* Soland.

SPECIES OF LORANTHUS	SPECIES OF HOST
Helicanthes elastica (Desr.) Dans.	*Grewia tiliaefolia* Vahl
	Zizyphus sp.
	Pithecolobium dulce Benth.
	Mallotus philippinensis M. Arg.
	Euphorbia antiquorum Linn.
Dendrophthoe neelgherrensis (S. & A.) Dans. (1300 m +)	* *Cryptomeria japonica* (Linn. f) D. Don
	* *Magnolia grandiflora* Linn.
	Mahonia leschenaultii Tak.
	* *Camellia japonica* Linn.
	Gordonia obtusa Wall.
	Eurya japonica Thunb.
	Nothapodytes foetida (Wy.) Sleumer.
	Ilex wightiana Wall.
	Ilex denticulata Wall.
	Microtropis ramiflora Wt.
	Turpinia cochinchinensis (Lour.) Mers.
	Meliosma simplicifolia (Roxb.) Walp.
	* *Acacia dealbata* Link.
	* *Acacia decurrens* Willd.
	* *Acacia melanoxylon* R. Br.
	Pygeum wightianum Bl.
	Photonia lindleyana W. & A.
	* *Prunus cerassoides* D. Don
	* *Syncarpia glomulifera* (Sm.) Nied.
	* *Eucalyptus globulus* Labill.
	* *Lagerstroemia indica* Linn.
	Schefflera racemosa Harms.
	Sehefflera capitata Harms.
	* *Luculia gratissima* SW.
	Viburnum punctatum Buch.-Ham. ex D. Don
	Xantolis tomentosa (Roxb.)
	Vaccinium leschenaultii Wt.
	Rhododendron nilagiricum Zenk
	Ligustrum lucidum Ait.
	Phoebe paniculata Nees
	Litseae ligustrina Hk. f.
	* *Hakea acicularis* Kn.
	Dendrophthoe falcata (Linn. f.) Etting.
	Celtis wightii Pl.
	Salix tetrasperma Roxb.
	* *Platanus orientalis* Linn.
	* *Quercus cerris* Linn.
Dendrophthoe memecylifolia (W. & A.) Danser (1500 m +)	*Pittosporum nilghirense* W. & A.
	Vaccinium leschenaultii Wt.
	Rhododendron nilagiricum Zenk
	Rapanea wightiana Mez.
Macrosolen parasiticus (Linn.) Danser (900 m, 1500 m-2400 m)	* *Cryptomeria japonica* (Linn. f.) D. Don
	Microtropis ramiflora Wt.
	* *Acacia melanoxylon* R. Br.
	Anogeissus latifolia Wall.
	Syzygium arnottianum Walp.

SPECIES OF LORANTHUS	SPECIES OF HOST
	* *Eucalyptus ficifolia* F.v. Muell.
	Maesa perrottetiana A.DC.
	Phoebe paniculata Nees.
	Cinnamomum wightii Meissn.
	* *Celtis serotina* Pl.
	Celtis wightii Pl.
	Salix tetrasperma Roxb.
	* *Ficus elastica* Roxb.
Macrosolen capitellatus (W. & A.) (1000 m-1500 m)	*Maesa perrottetiana* A. DC.
	Ficus tjakela Burm.
	Ficus spp.
	Artocarpus integrifolia Linn.

* introduced species

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. Sálim Ali for the inspiration and guidance he provided. The study was undertaken with financial assistance from the Bombay Natural History Society through a Sálim Ali/Loke Wan Tho Ornithological Research Fund Fellowship.

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ECOLOGICAL IMPACT OF AFFORESTATION AT THE RANIBENNUR BLACKBUCK SANCTUARY

S. G. NEGINHAL[1]

(*With two plates*)

INTRODUCTION

This paper deals with the ecological impact of afforestations on the populations of the Blackbuck *Antilope cervicapra*, the Great Indian Bustard *Choriotis nigriceps* and the Wolf *Canis lepus* at the Ranibennur Blackbuck Sanctuary of Karnataka State. These species had locally become almost extinct at Ranibennur on account of the destruction of their habitat and killings on a large scale, both by the villagers and poachers.

METHODS

No systematic census was carried out. Rough estimates of the Blackbuck *Antilope cervicapra* and the Great Indian Bustard *Choriotis nigriceps* were arrived at through several visits taking counts, assisted by the Sanctuary officials. Information was also derived from the 'frequency of sighting'. I also had the opportunity of personal contacts with several forest officers who worked in this area since 1958.

THE HABITAT

Abiotic Conditions :

The Ranibennur Blackbuck Sanctuary covers an area of 119 km^2 of open and undulating scrub forests near Ranibennur of Dharwar District, Karnataka State. It has vast expanses of grasslands. The configuration is flat and undulating, giving rise to gentle slopes and elevations (mounds) at places. The elevation ranges from 780 m to 985 m. The underlying rock chiefly consists of iron stone and quartz. The soil is very poor and lacks humus. It is shallow on the slopes and on the mounds and is eroded. The habitat is surrounded by agricultural fields where jowar, cotton, millets and oil crops are raised. The average annual precipitation is about 440 mm. The habitat receives both the south-west (June to August) and the north-east (September to November) monsoons, the latter contributing the major precipitation. The rainfall is, however, irregular and scanty. Drought and arid conditions generally prevail. All the streams cease flowing before the end of December and almost all water sources dry up in summer. The maximum temperature is around 38°C and the minimum around 20°C.

BIOTIC CONDITIONS

Flora :

From the abiotic conditions detailed above and the residual forests still occurring in the sanctuary it is evident that the ecosystem once supported a scrub type of forest at its climax. Kanitkar (1924) has recorded that the forests of Ranibennur were of scrub type which were already in poor and degraded conditions in 1924. So he had recommended replacing this silviculturally 'unsound and stunted growth' with a vigorous 'coppice and seedling growth'.

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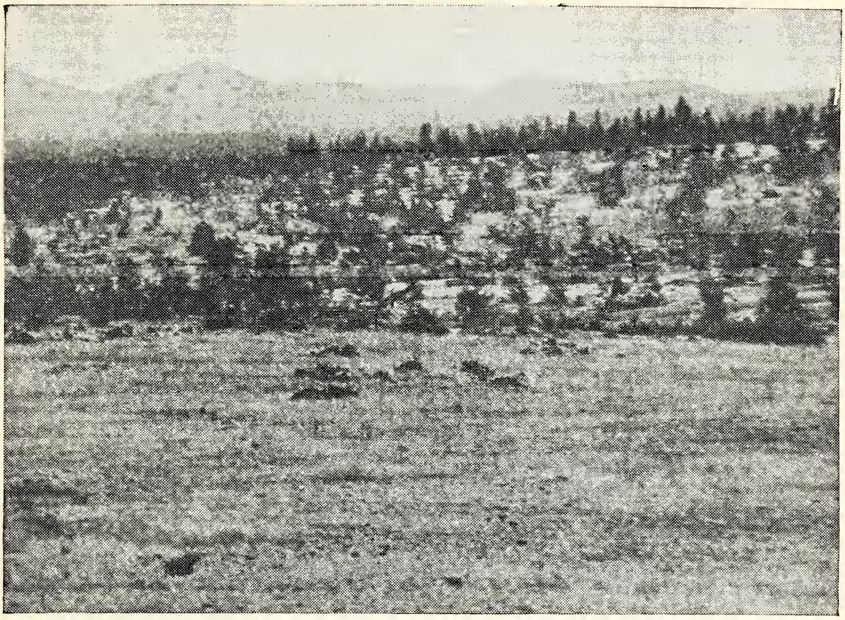
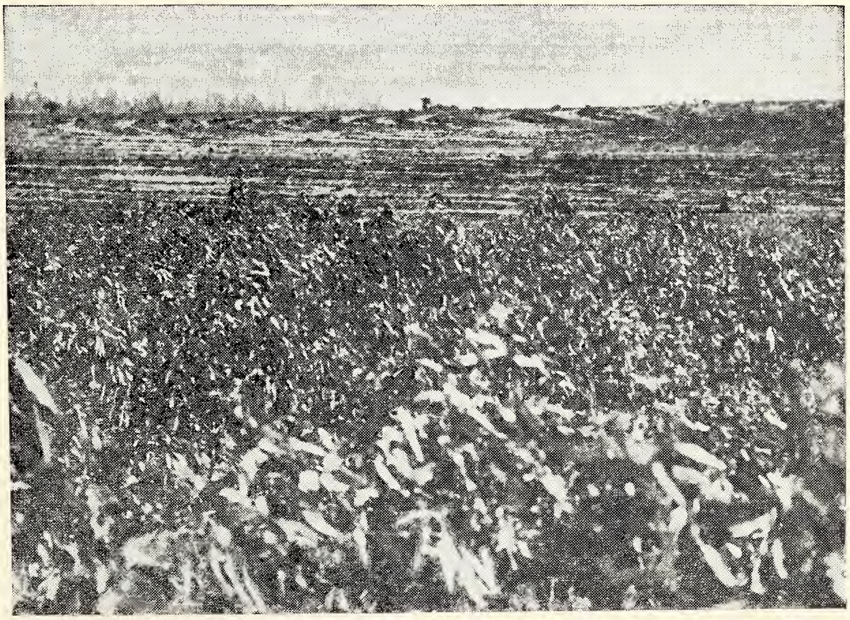
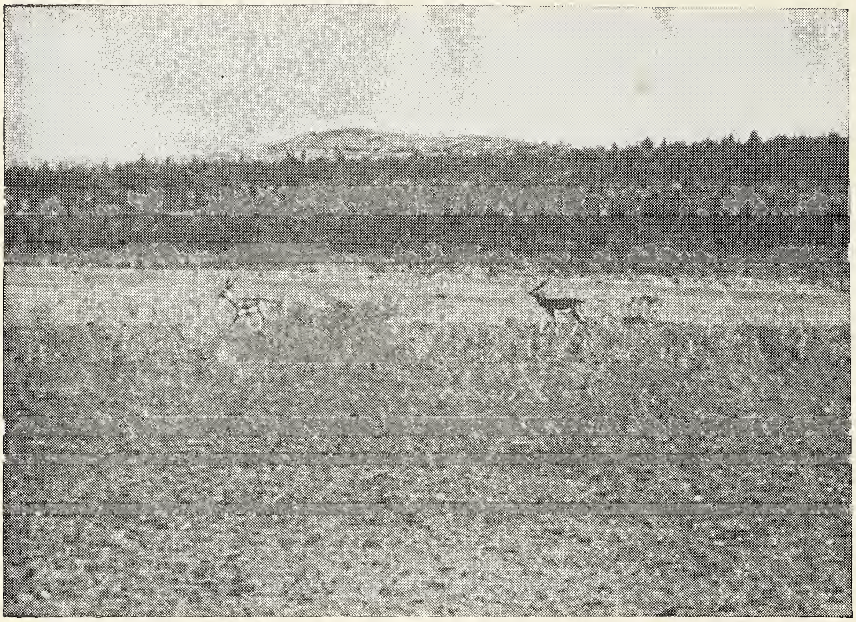
Neginhal: Ranibennur Blackbuck Sanctuary



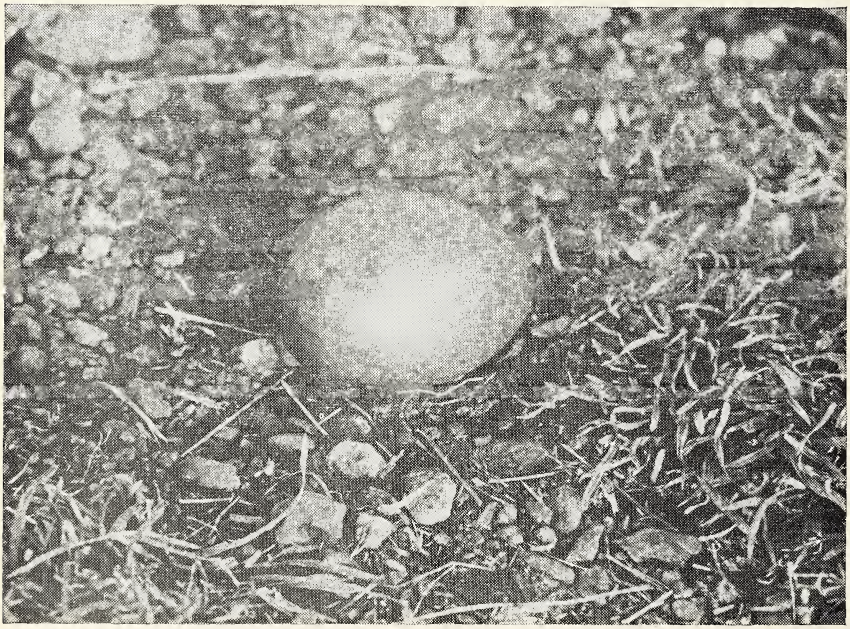
1. Afforested areas of Ranibennur, raised prior to 1972 by contour trenching, which provided sufficient open areas for blackbuck and bustard.



2. Mechanised afforestations from 1972 onwards created 'tall forests' of Eucalyptus and covered all open areas and even mounds, thereby discouraging blackbuck and bustard.



3. The blackbuck spending their time in the adjoining open agricultural fields than in the intensively afforested areas.



4. A Great Indian Bustard's nest and its large egg found in the Sanctuary.

The forest growth, as described by Kanitkar, consisted of the species of *Albizzia amara*, *Chloroxylon swietenia*, *Acacia* spp., *Hardwickia binata*, *Ixora parviflora*, *Euphorbia* spp., *Dodonaea viscosa*, *Carissa* spp., *Cassia auriculata*, *Lantana camara*, etc. Sandalwood *Santalum album* was found throughout the area. A fairly good growth of grass came up everywhere.

Wildlife :

No information on wildlife that existed in the area in 1924 is available. Kanitkar is silent about this rich inheritance. Local reports, however, confirm that the Ranibennur ecosystem supported in the past a varied and rich fauna such as the Blackbuck *Antilope cervicapra*, the Wild Boar *Sus scrofa*, the Wolf *Canis lupus*, and birds such as the Peafowl *Pavo cristatus*, and the Great Indian Bustard *Choriotis nigriceps*.

OBSERVATIONS

As prescribed by Kanitkar (1924), the scrub forests of Ranibennur were extracted and removed between 1924-1925 to 1954-1955. By 1958 the scrub forests were reduced to vast grasslands with scattered patchy growth of *Ixora parviflora*, *Euphorbia* spp., *Dodonaea viscosa*, and a few other scrub species. These degraded conditions were ushered in by the mounting influences of biotic factors of overgrazing, hacking and fires.

No wild animals were to be seen here in 1958. The blackbuck that reportedly moved in big herds in the past was not there. The great Indian bustard that had earned a local name as '*Yeraladdu*', suggesting its local abundance, was not to be seen.

From 1958 to 1971 attempts were made by the Karnataka Forest Department to afforest these barren areas by contour trenching. These manually dug contour trenches were of the sizes of 0.91 m × 0.61 m × 0.45 m, 1.83 m × 0.61 m × 0.45 m and 3.66 m × 0.45 m × 0.45 m and were staggered with a gap of 2 m in between two trenches and were vertically spaced at 9.15 m apart. Extensive denuded areas were also taken up for afforestation from 1970 onwards (Nadgouda 1977) to arrest soil erosion in the catchment areas of the Tungabhadra River of which Ranibennur formed a part.

In 1972 afforestation by manually dug trenches was replaced by mechanised afforestation. With the help of the heavy bulldozers, attached with specially designed rippers, the forest floor was ripped in lines at 2 m apart, instead of the spacing of 9.15 m apart earlier adopted during the manual trenching operations, and eucalyptus plants were planted 1.25 m and 1.5 m apart (Torvi 1975). Even the open space between the two rows of the previously afforested manually dug trenches was further ripped with the bulldozer and planted. More stress was also laid on planting eucalyptus hybrid, which soon grew to a height of 7-8 metres within 4-5 years. This mechanised afforestation from 1972 onwards went on drastically changing the entire structure and type of the habitat. The vast and expansive grassy blanks were covered by the fast growing eucalyptus hybrid over the years. So the open habitat of the blackbuck and the bustard went on shrinking ; and they were forced to shift their resting and breeding grounds to other open areas, which would also be ripped later for planting. (On an average about 640 ha. of this area is covered annually under mechanised afforestations.)

Moreover the operations involved in the mechanised afforestations offered much disturbance to the wildlife. The noise of the bulldozer scared away the blackbuck and the bustards. On account of its capacity to plough any hard ground, most of the grazing grounds of the blackbuck and the nesting sites of the bustards were lost.

In 1976 I observed the blackbuck spending more of their time in the open harvested agricultural lands that adjoin the sanctuary than in the sanctuary itself. It was also an ecological warning that the sanctuary was slowly becoming unfit for their use due to the thick and tall vegetation replacing their open-ground and stunted vegetation.

Prior to taking up afforestations in 1958, the Ranibennur was in a degraded condition. The rich scrub forests and the fauna that it reportedly supported in the past were destroyed by man. Even the fertility of the soil had come down and erosion was taking place. The 'Soil conservation and afforestation' measures taken up from 1958 onwards recovered the situation and rejuvenated the habitat. As grazing was stopped in the afforested areas, fodder grass came up. Seeds of local species, brought from outside, were sown on the manually dug trench mounds. So the once eliminated local species started establishing in the forest. The exotic fast growing eucalyptus soon surpassed the local species in height and growth and thus established itself as the dominant species. The eucalyptus, however, did not pose any problems initially as it was planted far apart (9.15 m). But as the years passed the eucalyptus shot up and ecologically changed the scrub type of habitat, where the height of the forest was not more than 2 metres, into a different habitat with its vegetational growth of 7 to 8 metres.

The measures taken to afforest the area had initially a remarkable effect on the fauna. The blackbuck that was reduced to near extinction in the Ranibennur slowly started recovering. In 1958 when afforestations were taken up the blackbuck was not noticed in the area, although a few must have existed. As afforestations proceeded and years passed, reports started trickling in from the forest staff of sighting the blackbuck moving in the area in ones and twos; and this soon grew into small herds as the years passed. In 1970 and 1971 I observed the blackbuck roaming over this area in large herds, congregating on the grassy plains and barren mounds which were not covered by afforestation (Neginhal 1974). In 1970 I had estimated the population of blackbuck to be about 600 by visual counts. In September 1971 this habitat was constituted as a blackbuck sanctuary (based on my report), covering an area of 119 km². In my 1974 visit the population of blackbuck was still on the increase and my visual count put the population around 1000.

This spurt in the population of the blackbuck was not a healthy sign in the absence of a predator, and I was wondering how nature would respond to this requirement. Nature soon met this situation by bringing in a predator. In 1973 a wolf was reported in the sanctuary and 2 years later a wolf was sighted with cubs (Krishnan 1975).

In 1971 the Great Indian Bustard, an endangered species, was sighted in the sanctuary authentically for the first time. These birds soon started breeding here. In 1974 I counted 15 birds and in May 1976 I saw and photographed a nest with an egg (Neginhal 1976). The other important birds seen were the Common Sandgrouse *Pterocles exustus*, the Indian Courser *Cursorius coromandelicus*, the peafowl and the Pale Harrier *Circus macrourus*.

The intensive work of afforestations has also affected the indigenous flora, so typical of the open scrub forests of the Deccan. The *Acacia* spp., *Euphorbia* spp., *Ixora parviflora* and other indigenous floral patches where the bustard used to shelter have disappeared now.

The eucalyptus hybrid, a variety selected initially in 1958 for its fast growing and hardy nature, later found to be of industrial use in the manufacture of rayon and paper pulp, posed a further danger to the habitat owing to the disturbance caused while cutting and transporting the wood.

DISCUSSIONS AND CONCLUSIONS

The blackbuck, the wolf, the fox and the Great Indian bustard were not reported in the Ranibennur habitat in 1958, when the afforestations were started. Afforestations were taken up from 1958 to 1972 with wide spaced manually dug trenches. The blackbuck rose to a population of 600 in 1970 and to 1000 in 1974. The wolf was spotted in 1973. The Great Indian bustard was first sighted in 1971 and rose to a population of 15 in 1974 and remained almost constant in 1976.

Prior to carrying out afforestations, the blackbuck population must have been reduced to imperceptible proportions due to adverse biotic factors to which the habitat was subjected, such as heavy grazing, hacking, fires and poaching. The afforestation work increased the carrying capacity of the habitat. It gave indirect protection against the poachers on account of the constant presence of the forest staff engaged in afforesstation-cum-soil conservation works. As the grazing was restricted and was closed in the afforested parts, grass came up profusely and provided ample food to the blackbuck. This was supplemented by the indigenous vegetation that came up on account of the stoppage of grazing. The grass and other vegetation also offered the much needed shelter and cover. So the adverse factors decreased as the welfare factors increased in proportion. This gave a boost to the natality rate while the mortality was far reduced. On account of these favourable conditions the population of blackbuck kept increasing rapidly.

As the population of blackbuck increased along with an increase in the small mammals and birds, favourable conditions were set for sustaining a predator; and this came in the form of the wolf.

The afforestations work also created congenial environmental conditions for the Great Indian bustard. However, the intensification of afforestations by mechanised means started clothing whatever open areas were available with tall growth of fast growing vegetation and this poses a great threat to the blackbuck and the bustard. With the help of heavy bulldozers the remaining open grassy patches, used for roaming and breeding by the blackbuck and the bustard, were ripped and planted intensively within no time. The afforestations with exotics also endangered the local flora.

The blackbuck and the bustard are evolved for open habitat and hence they thrive best in open plains scattered with scrub growth. Sálim Ali (1969) refers to the Great Indian bustard as a species affecting wide open spaces of scanty grassland interspersed with scrub. Prater (1948), Schaller (1967) and Krishnan (1972) gave the habitat of the blackbuck in open forests and open meadows. The wolf too prefers open scrub areas. In the initial years of afforestations from 1958 onwards the general conditions and characters of the 'scrub and grass' continued to prevail in the environment. The initial low height of the plants, especially of eucalyptus, did not pose any ecological problems to these animal and bird species. But soon the habitat changed. The stunted condition of the 'scrub forests' changed to a tall 'forest growth' on account of the fast growing eucalyptus which reached a height of about 8 metres within about 4-5 years. This 'tall forest' started covering the existing bare areas, year by year, on account of the progressive afforestation works, thereby shrinking the habitat of the blackbuck, the bustard and the wolf. The habitat is becoming unsuitable for the existence of these species.

In course of time the habitat may even

replace the blackbuck with the Spotted Deer *Axis axis*, the wolf with the Leopard *Panthera pardus*, the great Indian bustard with the Grey Junglefowl *Gallus sonneratii*, the Indian courser with the lapwings (*Vanellus malabaricus* and *V. indicus*). Should we desire this ecological succession which would eliminate the endangered blackbuck,the great Indian bustard and the wolf that Nature has attempted to rehabilitate in this ecosystem in the question.

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Note : In 1979 I again visited this sanctuary and could trace only one bustard as against 15 spotted in 1974. Most of the Blackbuck were found in the surrounding agricultural fields than in the sanctuary. A leopard was also reported prowling in the sanctuary.

HUMAN-ANIMAL INTERACTIONS IN THE RAJASTHAN DESERT

ISHWAR PRAKASH[1] AND P. K. GHOSH

INTRODUCTION

The north-western and western parts of Rajasthan comprising the arid and semi-arid districts of Barmer, Bikaner, Churu, Ganganagar, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur' Pali, Sikar and Sirohi—have harboured a large variety of fauna since proto-historic times (Sankhala 1964 ; Prakash 1975). Archaeological evidences and historical records indicate that in the not-too-distant past, the tract abounded in several species of wildlife that no longer exist here. For example, excavations carried out at sites of mesolithic culture in the Luni basin, particularly near Tilwara in Barmer district have unearthed charred bones of the spotted deer *Axis axis* and the hog deer *Axis porcinus*, besides a host of other species,—both of which have now disappeared from the desert scene. These finds also point to the prevalence of a combination of hunting and stock-raising economy in this region in the mesolithic period. The archaeological finds also suggest that in times of antiquity, the jackal *Canis aureus* and the Domestic dog *Canis familiaris* were perhaps as much preferred for their meat as the herbivores. Today, consumption of the meat of such carnivorous animals is restricted to only a few tribes or sects. In historical times, western Rajasthan provided enough opportunities to the sporting nobility to test their mettle (Prakash 1960). The first Mughal emperor, Babur, has left behind vivid narratives of his hunting expeditions in this tract and in adjacent Sind where the Asiatic lion was not scarce at all. In all probability, the lion had its sway over much of the Rajasthan desert until comparatively recent times. Besides the lion, the region could easily boast of a surprising variety of wildlife, only a fraction of which has managed to survive to this day. Culturally speaking, the people of Rajasthan have, over the centuries, developed a dichotomous attitude towards wildlife. On the one hand, there were the Rajputs—the princely caste—and their minions, besides a number of nomadic and forest-dwelling tribes—who looked upon hunting of wildlife as one of the more manly pastimes and revelled in killing whatever game came their way. On the other extreme of the psycho-social spectrum there were the believers in absolute non-violence, particularly, those belonging to the trading communities, brahmins and practising *Jains* and some other religious sects.

HUMAN-ANIMAL INTERACTIONS

A desert community of people called the *Vishnoi* occupies a distinctive position in this arrangement. These people nurse a peculiarly strong inhibition towards the killing of the Blackbuck *Antelope cervicapra*, but are not particularly against destruction of other forms of wildlife. To a *Vishnoi*, the blackbuck, any blackbuck, represents one of his ancestors and, as such, is an object of veneration. It will be no exaggeration to say that but for the aggressive protection afforded by the *Vishnois* to this beautiful antelope species, it would have vanished from the desert scene, as have vanished (or almost vanished) the panther, the Great Indian Bustard *Choriotis nigriceps* and the Wild Boar *Sus scrofa*. We have witnessed what results people's active involvement in wildlife preservation can achieve. In the Dawa-Doli Blackbuck Sanctuary situated about 40 km west of Jodhpur, and managed by the Rajasthan Forest Department, there are now about 3000 blackbuck of both sexes and all age groups. The sanctuary is fortunately surrounded by *Vishnoi* villages and is, thus, not the least dependent upon the vigilance of the government guards for the protection of its denizens. They are lovingly protected at all times by the whole populace and the result is worthy of emulation in all parts of the world. They even provide grains and water to the animals during droughts and engage people to look after the needs of animals in remote areas. We would consider the *Vishnoi* as perhaps the only such group of people with such zeal for affording protection to a wildlife species. Should not the IUCN and the World Wildlife Fund recognise the meritorious services of the *Vishnois* in the cause of wildlife preservation by at least an honourable mention of their sustained efforts ?

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[1] Central Arid Zone Research Institute, Jodhpur.

As far as the nobles were concerned, it has been a ' shoot-at-sight ' in certain cases and a logical and seasonal harvesting of wildlife, development of game sanctuaries and systematic management and breeding of different species—in other cases. The sagacity of the former Maharajas of Bikaner with regard to wildlife management—for game purposes, of course—speaks for itself in the form of the beautiful Gajner Sanctuary—the winter resort of the imperial sandgrouse and the favourite habitat of the chinkara *Gazella gazella* and the blackbuck. Similarly, the erst-while Maharajas of Jaipur have left us the legacy of the wildlife wealth of Sawai-Madhopur while the princely house of Alwar had preserved for posterity the excellent Sariska Sanctuary. The Ghana Bird Sanctuary of Bharatpur is another example of man's appreciation of wild beauty.

During days of the princes, it was the prerogative of the Rajas and nobles to hunt in the state forests. Poachers and defaulting commoners were severely punished for any violation of the rules. The situation totally changed since 1947. While the Indians got their political independence, they also got the freedom to totally annihilate their wildlife (Prakash 1958). Merciless, thoughtless, ruthless killing of all wildlife became the order of the day, and the desert soon became bereft of some of its most precious jewels that Nature had adorned her with. Fortunately for all of us, the mad frenzy for wanton killing has given way to a little bit of rational thinking. The high-powered jeep with blinding flash-light and the high-velocity rifle is no longer the ruler of the desert night—even though it is still not an uncommon exception. Hopefully, the day is not far off when all of us will feel a positive attraction for our wildlife. At the moment, for most of us, a bird or an animal is just a bird or an animal, with no special significance. We are rather insipid, non-involved or down-right callous in our attitude towards wildlife. What we need is a tiny shot of the *Vishnoi*'s protective spirit in our arms—and all our wildlife will be safe.

We have already paid a heavy price for our callousness. We have been silent spectators of the mass slaughter of a great many species and in some cases the germ plasm has been lost for ever. The desert sands no longer reverberate to the thunderous roar of the lion, nor does the sleek cheetah survey the horizon from the height of a mound and then, in a flash, almost glides through the air to prey on a herd of unwary blackbuck serenely grazing under the shadow of a dune. The wild boar too has had its day, and we may never encounter them in lonely paths as our ancestors used to do so commonly. We have lost much. But we still have that magnificent bird—the great Indian bustard and the smaller, though equally attractive, game-bird—the Houbara *Chlamydotis un-*

dulata in sufficient numbers to allow reasonably stable population build-up of these two species in this tract. We are also fortunate that the desert still abounds in the fleet-footed chinkara and the blackbuck.

FUTURE PLAN

Lest we lose even these few remnants of our heritage for ever, efforts are under way to organize a Desert National Park near Pokaran in Jaisalmer district where these graceful birds and animals will be allowed to live and breed in their own ecological niche and without the fear of man. Attention must, however, be paid to restore climax conditions in the Desert National Park even if it has to be done by irrigating the grasslands by tube well water. Any rejuvenation of wildlife in the present degraded land will be almost impossible. A development plan for wildlife in the Thar Desert has been proposed in another communication (Prakash 1975).

ACKNOWLEDGEMENT

Our thanks are due to the Director, Central Arid Zone Research Institute, Jodhpur for encouragement and support.

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HEALTH PERSPECTIVES FOR WILDLIFE CONSERVATION

C. M. Singh[1]

It is well known that changes have been occurring since prehistoric times in the population numbers of various animal species and that these changes are influenced by a complex interplay of a wide variety of ecological factors. A number of these factors related to physical and biological characteristics of ecosystems are generally recognised and have received attention. There is, however, little knowledge and appreciation of the role of highly contagious and fatal epizootics, some of which affect a wide range of animal species over large areas, in the population changes in wildlife that have been observed over certain periods of time.

During the past century, human activities have considerably hastened the process of decrease in numbers or even extinction of some species of wildlife. Owing to the increasing land use for agricultural operations and consequent progressive decrease in forest areas, there is already a growing tendency to conserve wildlife in the limited geographic areas of national parks and wildlife sanctuaries.

Under these conditions, the prevalence of epizootics among wildlife is likely to play a more important and crucial role in the population dynamics of wildlife. Therefore, there is an urgent need to determine the nature and the extent of epizootics encountered among different species of wildlife in the country. A clearer understanding of the diseases that may influence the mortality rates in free living wild animals, will be helpful not only for adopting more effective steps for conservation of our valuable wildlife, but also for devising measures to decrease the perpetual hazard of spread of some of the diseases in wild animals to and from domestic animals and man.

Epidemiological aspects of some of the epizootics encountered in different species of wildlife in the country are briefly summarized in spite of the fact that not much information is available in the published literature.

Rinderpest :

The devastating effect of this pestilence of the Gaur *Bos gaurus* population in wildlife reserves and sanctuaries in the country, has been reported on a number of occasions during the past fifty years (Burton 1953). This disease has accounted for the death of a large number of gaur and wild buffalo in peninsular India (Editorial 1927). As early as 1935, Sálim Ali drew attention to the fact that large tracts of game country have been known to be ravaged by rinderpest and foot and mouth disease contracted from infected cattle left to graze in forests inhabited by wild animals. More recently this disease had almost wiped out the gaur populations of Mudumalai Sanctuary in 1968 and Periyar Sanctuary in 1974.

Ray and Samanta (1974) reported the occurrence of a syndrome simulating rinderpest at Calcutta zoo. The disease attacked Nilgai *Boselaphus tragocamelus*, gayal *Bos frontalis* and hog deer *Axis porcinus*. The case fatality rate was 61 per cent. Virological studies were not done. The disease was controlled by administration of caprinised rinderpest vaccine to other artiodactyles and institution of quarantine measures.

The disease is believed to spread from the infected domestic cattle and buffaloes to the wild animals through common pastures. In addition to the bovines, many other artiodactyls may contract this disease. Among the wildlife in this country, these include Sambar *Cervus unicolor*, Nilgai, Yak etc. The epidemiologic characteristics of the disease encountered in these species are not known. It is also not known whether epizootics may occur which may remain confined to the gaur population while the disease has not been noticed in the domestic bovine population in the area over the period of time preceding the observed outbreak in wildlife. The possibility of any other species of wildlife becoming carriers of rinderpest virus infection during the inter-epizootic periods has not been investigated.

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Foot and Mouth Disease :

Outbreaks of Foot and Mouth disease (FMD) in the gaur populations associated with high mortality have been reported to occur frequently during the past several decades. Sálim Ali (1935) reported that an entire herd of gaur perished from foot and mouth disease at Manikgarh in Hyderabad State. From the information received by him it appeared that in a similar epidemic hundreds of animals perished in Warangal district. Morris (1952) reported the death of 15,620 'bison' due to foot and mouth disease contracted from village cattle penned in hill forests owing to lack of grazing down below. FMD is a highly contagious disease with a wide host range among artiodactyls and has a high morbidity rate among several species of domestic animals. The disease may occur in animals other than artiodactyls such as hedgehogs, and even rats have been considered potential carriers. There is some evidence to suggest that elephants *Elephas maximus* may also contract infection. It has been contended that the presence and the persistence of FMD virus infection in certain species of wild animals may play a vital role in the general epidemiology of this disease (McDiarmid 1975).

Rabies :

In India, apart from the domestic dog which is generally acknowledged as the most common transmitter of urban and rural human rabies, a number of wildlife hosts such as the wild dog, jackal, wolf, fox, jungle cat and mongoose are known to contract and transmit the disease to other susceptible animals and man. However, there is little reported information on the sylvatic rabies cycle in the country. It is known that rabies tends to cycle within host species and only rarely spills over to other species so that it may be present in jackals or foxes without being observed for many years. The extent of wildlife rabies hazard to man and the domestic livestock, is illustrated by a recent observation reported by Shah and Jaswal (1976). In February 1973 a rabid wolf travelled over 23 km in 12 hours in Aurangabad district and attacked 12 persons and 6 domestic animals in 15 different places. Three persons and 3 animals died of rabies. One animal died of injuries immediately after the attack. One pig that was bitten, became aggressive and was killed and buried. This was dug up and eaten by 4 dogs. One of these dogs had onset of rabies 12 days later. All the 4 dogs were destroyed.

Anthrax :

This fatal disease has a wide range of hosts. The disease is endemic in the country and almost all species of domestic herbivores are susceptible. There is, however, little information on the incidence of this disease in wildlife. According to Lahan and Sonowal (1973) this and another unidentified disease were responsible for heavy casualties among rhinoceros population in Kaziranga wildlife sanctuary in 1944 and 1947.

African Horse Sickness :

A large number of wild ass were reported to have died of African horse sickness in November and December, 1961 in the little Rann of Kutch. Again there was an epidemic among wild asses in October and November 1964 when a forest guard claimed to have seen about 100 dead asses between Jesda and Malvan (Spillett 1968). The disease was contracted from domestic equines. This disease has not been reported since and hence possibly eradicated from the country

Leptospirosis :

It is well known that the wildlife plays an important role in the epidemiology of leptospirosis. Continuing search for sources of infection for domestic animals and man has revealed an expanding host range in the wildlife belonging to five orders of the mammals, namely, Rodentia, Lagomorpha, Insectivora, Chiroptera and Artiodactyla (Twigg *et al.* 1969). Besides domestic livestock and laboratory animals, already pathogenic leptospires have been isolated from 118 species of wild mammals and 2 species of birds (Communicable Disease Centre 1966). Small animals belonging to families Muridae, Erinacidae and Soricidae are the primary hosts and the main source of infection for most of the leptospiral types infecting man and domestic animals.

Leptospirosis is prevalent in the domestic livestock and human populations in the country. However, so far little work has been done to survey leptospiral infection in wildlife and, therefore, there is no published information on its prevalence among the wildlife species.

Parasitic infections :

There is little published information on the prevalence of parasitic infections in wildlife and their impact on population dynamics of different species of wild animals in this country.

In 1958 and 1960 Surra accounted for some deaths in the wild ass in the little Rann of Kutch (Sálim Ali—cited by Spillett 1968). The domestic equines and bovines (possibly a number of other species) may harbour the infection which is transmitted from the infected to susceptible animals through insect vectors, mainly the Tabanid and *Stomoxys* flies.

However, Warble grub infestation in chinkara was reported at Hissar, from the material obtained from the Assistant Superintendent, Cattle Farm, Hissar (Annual Report, IVRI, 1931).

Occurrence of *Muticaecum* sp. was reported from stomach tumour of an Indian crocodile at Jullunder (Annual Report, IVRI, 1934). Another report is on the nematode causing stomach tumour in Indian crocodile (Annual Report, IVRI, 1935). Occurrence of *Gastrothylax* sp. was reported from the stomach of a ' bison ' (Annual Report, IVRI, 1942-43).

Disease among non-human primates :

Several species of non-human primates which inhabit different parts of this country, are prone to suffer from a variety of epidemic and other diseases, most of which are communicable among these animals and man. Because of their high susceptibility to some of the diseases transmissible to human beings, these simians may even serve as sentinels of human disease as was observed in the case of Kyasanur forest disease. This disease caused by an arbovirus of the Russian Spring Summer Encephalitis (RSSE) Group had not been known to occur in India until 1955. Late in 1955, a large number of Bonnet Macaques *Macaca radiata* and Common langurs *Presbytis entellus* were found dead in Kyasanur forest area in Karnataka. About the same time, cases of a severe fibrile illness called the ' monkey disease ' by the natives occurred among the humans in this area. A second outbreak began early in 1957 over a much wider area. Investigations by the Virus Research Centre, Poona showed that the disease in both monkeys and man was caused by an arbovirus closely related to the virus of RSSE, which might be epidemic in Western Siberia (Webb 1969).

Deaths from tuberculosis have been recorded among Rhesus macaque *Macaca mulatta* (Krishnan 1936 ; Singh *et al.* 1951 ; Nair and Ray 1955). A fairly high proportion of monkeys exported from India have been found to suffer from Salmonellosis (Rowe 1969) Shigellosis (Cook 1969) and several other bacterial and viral infections. Monkeys in this country have also been shown to suffer from malaria caused by *Plasmodium cynomolgi* (Prakash and Chakrabarti 1962) and *P. fragile* (Choudhary *et al.* 1963).

PATHOLOGICAL EXAMINATION

During the five years from 1972, a good number of morbid materials have been received at the Division of Pathology of Indian Veterinary Research Institute, Izatnagar, from different Zoological Parks, etc. for investigation and diagnosis of the disease conditions in the wild animals. Although efforts are made to diagnose the disease from such materials, on many occasions a definite diagnosis could not be ascertained due to either the unsuitability of the material or specific material needed for other laboratory tests was not available. The details of the diagnosis of the specimens are given in table 1.

While most of these syndromes may be responsible for sporadic cases and tissue damage in vital organs such as lungs, kidneys, and liver (characterised by pneumonia, hepatitis, nephritis etc.), some of the diseases such as canine distemper and feline viral enteritis can prove extremely dangerous for wildlife members of dog and cat families which are susceptible to these diseases and may suffer heavy mortality.

The available information on the reported occurrence of a number of epizootics which were responsible for heavy mortality among different species of already declining wildlife populations during the past several decades clearly points to the urgent need for effective measures to minimise losses from these diseases. This in turn would necessitate wildlife surveys to determine the prevalence of disease in different species of wildlife and investigations to elucidate the nature of relationships between the domestic livestock and the wildlife which causes the spread of disease between them. Some insight into the diseases of free living wildlife can also be gauged by extending these studies to captive animals in the zoological gardens and limited colonies maintained for biomedical research.

At the Indian Veterinary Research Institute in the Division of Epidemiology, we have a Wildlife Section which is exclusively concerned with the study of wildlife diseases. In this Division, already we have, in collaboration with the Zoological Survey of India, taken up a project for population census and survey of infections in Rhesus monkeys and Common Langurs in India. Under this project, materials collected from monkeys through field teams in different parts of the country will be examined for bacterial, viral, mycotic and parasitic infections. In due course, it would be possible to extend the scope of such surveys to other wildlife species keeping in view the priorities in terms of extent of threat from disease to the wildlife.

It is of utmost importance that animal disease surveillance and monitoring is scrupulously carried out in the core area of wildlife sanctuaries and national parks besides strict quarantine and prophylactic measures. Moreover, a strict watch has to be kept on domestic animals in grazing area in the forests surrounding the core area of wildlife sanctuaries and national parks to safeguard against spread of infection through domestic animals.

TABLE 1

DIAGNOSIS OF THE SPECIMENS

Source	Animal	Diagnosis
	NON-HUMAN PRIMATES	
Delhi Zoological Park, New Delhi	Golden Langur (*Presbytes geei*)	Malaria and anaemia.
-do-	Chimpanzee (*Pan troglodytes*)	Traumatic myositis and cellulitis.
-do-	Pig-tailed Macaque (*Macaca nemestrina*)	Tuberculosis (Pulmonary).
-do-	Japanese Monkey (*Macaca fuscata*)	Catarrhal enteritis.
-do-	Chimpanzee (*Pan troglodytes*)	Acute pneumonia.
-do-	Slender Loris (*Loris tardigradus*)	Hepatic degeneration.
Gemini Circus	Chimpanzee (*Pan troglodytes*)	Amoebic appendicitis and rupture.
Asstt. Director, Vety. Services, Gwalior.	Chimpanzee (*Pan troglodytes*)	Tuberculosis (Pulmonary).
Vety. Biol. Res. Instt., Hyderabad.	Liontailed Macaque (*Macaca silenus*)	Endometrial adenocarcinoma.
	UNGULATES	
Delhi Zoological Park, New Delhi.	American Bison (*Bos bison*)	Acute asphyxia.
-do-	Indian Gazelle (*Gazella gazella*)	Supp. pneumonia and enteritis.
-do-	Spotted Deer (*Axis axis*)	Tuberculosis.
-do-	Sikka Deer (*Cervus nippon*)	Subacute pleurisy.
-do-	Musk Deer (*Moschus moschiferus*)	Acute venous congestion.
-do-	Indian Gazelle (*Gazella gazella*)	Coccidiosis.
Vety. Biological Res. Instt., Hyderabad.	American Bison (*Bos bison*)	Subacute cystitis.
-do-	Indian Gazelle (*Gazella gazella*)	Lung abscesses.
	CARNIVORES	
Delhi Zoological Park. New Delhi	Hunting Cheetah (*Acinonyx jubatus*)	Lipomatosis.
-do-	Panther (*Panthera pardus*)	Hepatic cirrhosis.
-do-	Lesser Panda (*Ailurus fulgens*)	Bronchopneumonia with lungworm.
-do-	Striped Hyena (*Hyaena hyaena*)	Subacute cellulitis.
-do-	Lesser Panda (*Ailurus fulgens*)	Acute bronchopneumonia.
-do-	-do-	Canine distemper.
-do-	Marbled cat (*Felis marmorata*)	Anaemia and metaplasia in liver.
Dy. Director, Vety. Services, Dis. Invest. Bhopal.	White tiger (*Panthera tigris*)	Chronic nephritis.
Delhi Zoological Park, New Delhi.	Kinkajou (*Potos caudivelvulus*)	Acute bronchopneumonia.
	OTHERS	
Delhi Zoological Park, New Delhi.	Golden Agouti (*Dasyprocta agnti*)	Nephrolithiaiss and hydroenephrosis.
-do-	Kangaroo (*Macropus* spp.)	Bronchopneumonia.
-do-	Giant Squirrel (*Ratufa indica*)	Toxic change in liver.
Asstt. Director Vety. Services, Gwalior.	Kangaroo (*Macropus* spp.)	Foetal acute bronchopneumonia.

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